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STUDIES ON FACTORS IN BEEF CATTLE PRODUCTION IN A SUBTROPICAL ENVIRONMENT 1. BIRTH WEIGHT

By G. I. ALEXANDER, B.V.Sc., M.S., Ph.D.,* D. N. SUTHERLAND, B.V.Sc.,† GILLIAN P. DAVEY, B.Sc.,†† and M. A. BURNS, Q.D.A.H.§

SUMMARY

Data from 502 calves from 244 cows during the years 1954-1957 at "Brian Pastures" Pasture Research Station of the Queensland Department of Agriculture and Stock were analysed. The effects of sex, year of birth, age of dam, weight of dam and time of birth on birth weight were evaluated.

The mean birth weight of all calves was 70·4 lb. The male calves weighed 4·7 lb. more than the female calves, the difference being significant. Significant year differences were recorded due to the marked lowering of birth weight following the 1957 drought. First-calf heifers gave birth to calves which were 4 lb. lighter than those of mature cows.

Weight of dam was significantly related to birth weight and was associated with approximately 6 per cent. of the variation in birth weight of the calf. Time of calving, in a 3-month calving period, also was significantly related to birth weight but was only associated with 3 per cent. of the variation in the birth weight of the calf.

The repeatability of birth weight was 0·25 and that of weight of dam was 0·86.

I. INTRODUCTION

Beef cattle production in Queensland is carried on under a wide variety of seasonal conditions, but in most cases beef cattle are produced entirely on unimproved pasture. Since little supplementary feeding is practised, the growth rate of the livestock is somewhat seasonal, being largely influenced by the quality and the quantity of pasture available. The seasonal nature of this growth curve has been discussed and various methods of making growth more continuous have been suggested (Chester 1952; Alexander and Chester 1956; Shelton 1956; and Sutherland 1959).

This is the first of a series of papers in which the growth of the beef animal is considered at certain strategic periods in its life, and the influence of the various relevant factors evaluated.

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II. EXPERIMENTAL PROCEDURE

The study recorded here was based on the birth weights of 502 calves from 244 cows during the years 1954 to 1957, inclusive, at "Brian Pastures," in south-eastern Queensland. This station is owned by the Australian Meat Board and operated by the Queensland Department of Agriculture and Stock as a pasture research station with special reference to beef cattle. It is situated on the western bank of Barambah Creek, about 10 miles from Gayndah in latitude 25° 40′S. The average rainfall of the district is about 29 in., and the rainfall is mainly of summer incidence. The property consists of ridges of varying slopes and broken areas of levee bank and flood plain regions along the creeks. The vegetation was originally an open eucalypt forest and the pasture grasses are now mainly *Heteropogon contortus* (black spear grass) and a number of blue grasses (species of *Dichanthium* and *Bothriochloa*).

Marked seasonal fluctuations in the growth rate of cattle have been reported on this property by Alexander and Chester (1956) and Sutherland (1959). The calving season usually extended over approximately 10 weeks from late October to early January. The ages of the cows at the birth of all the calves were known. The cows were either Hereford or Poll Hereford cows mated to Poll Hereford bulls. Each of the breeder paddocks was ridden over daily during the calving season and all newborn calves were caught, numbered, weighed and identified with their dam as described by Burns and Alexander (1956).

The relation of birth weight to sex of calf, year of birth, age of dam, weight of dam and time of birth was studied.

The data were analysed by statistical procedures as described by Snedecor (1958) and Anderson and Bancroft (1952). A preliminary analysis indicated that (1) interactions were unimportant and (2) regressions could be regarded as homogeneous from year to year. An additive linear model was therefore fitted by least squares, constants being fitted for years, sex, first-calf heifers *v.* adult cows, and cows.

Variates considered were the birth weight of the calf and the weight of the dam in the May previous to calving. The latter was used as it was considered indicative of the size of the cow and because the weights immediately prior to and following calving were not available.

III. REVIEW OF LITERATURE

(a) Sex

Bull calves have been consistently reported to be significantly heavier than heifer calves. Dairy bull calves have averaged 4·8 lb heavier than heifer calves (Eckles 1919; McCandlish 1922; Fitch, McGilliard, and Drum 1924; Knapp, Lambert, and Black 1940; Tyler, Chapman, and Dickerson 1947; and Braude and Walker 1949).

In the beef breeds, the sex difference appears to be of a similar order. Knapp, Baker, Quesenberry, and Clark (1942) found that Hereford male calves at the Miles City Range Livestock Experiment Station in Montana for the period 1926–1940 averaged 5·8 lb heavier at birth than females. Dawson, Phillips, and Black (1947) compared the birth weights of bull and heifer calves from the Shorthorn herd at Beltsville, Maryland, and found that male calves averaged 4·2 lb heavier than females when their birth weights were adjusted to the basis of 6-year-old dams. Gregory, Blunn, and Baker (1950), studying Hereford calves at two Nebraska experiment stations, showed that the males averaged 5 lb and 4 lb more at birth than the female calves. Burris and Blunn (1952) examined the birth weights of Aberdeen Angus, Hereford and Shorthorn cattle. Males of the three breeds averaged 5·3, 4·5 and 4·9 lb respectively heavier at birth than females. In a study by Botkin and Whatley (1953), Hereford male calves were 4·4 lb heavier than females at birth. Koch and Clark (1955), using records of 5,952 Hereford calves at the Miles City Range Livestock Experiment Station, showed bull calves to average 5·6 lb heavier at birth than female calves. In a more recent and more comprehensive examination of the Miles City data, Clark, Shelby, Quesenberry, Woodward, and Willson (1958) found that birth weights differed between sexes, males averaging 5 lb heavier than females.

(b) Year Differences

In almost every investigation made of factors affecting birth weight of calves, significant year differences due to drought years have been reported. Knapp *et al.* (1942) demonstrated that birth weight varied relatively little from year to year except in years following drought. However, Burris and Blunn (1952) found that year differences were not significant. Clark *et al.* (1958) found birth weight to vary considerably among years. It decreased after a year of extreme drought or after an extremely severe winter. In general, birth weight seemed to be little affected by environmental conditions unless they were extremely severe.

(c) Age of Dam

Age of the dam has an influence on the birth weight of the calf. Calves from 2-year-old cows were found by Knapp *et al.* (1942) to be about 10 lb lighter than those from mature cows, while the change in age of the cow had little effect on birth weight after four years of age. Burris and Blunn (1952), in a study of Aberdeen Angus, Hereford and Shorthorn cattle, found calves from 2–3-year-old cows to average 4·7, 4.9 and 6.0 lb lighter at birth than calves from 4–5-year-old cows and calves from 3–4-year-old cows to average 3·0, 1·3 and 1·9 lb lighter than those from 4–5-year-old cows. Birth weight reached its maximum when cows of the Aberdeen Angus, Hereford and Shorthorn breeds, respectively, were 10–11, 11–12 and 10–11 years old. Rollins and Guilbert (1954) showed that the effect of age of dam was smaller for female than for male calves. Koch and Clark (1955),

using Hereford cattle, computed factors for adjusting birth weight to a mature-dam basis. Calves from 3-year-old and 4-year-old cows were 4 and 2 lb lighter than those from mature cows, while calves from 10-year-old cows were 2 lb lighter than those from cows aged between five and nine years, inclusive. Clark *et al.* (1958) reported similar findings with Hereford calves. Age of dam had an effect on the birth weight of calves from 3-year-old cows as compared with calves from older cows but otherwise was of little importance in relation to birth weight. Male and female calves from 3-year-old cows averaged 4 lb lighter at birth than those from 5–10-year-old cows. Male and female calves from 4-year-old cows averaged 1 and 2 lb lighter respectively than those from the older class.

(d) Weight of Dam

Since the weight of the dam is closely related to the age of the dam, studies evaluating this factor have been made when age has been held constant. A correlation of + ·26 was found between birth weight of calf and previous-fall weight of dam by Knapp *et al.* (1942). Gregory *et al.* (1950) calculated a correlation of + 0·21 between birth weight and cow weight after calving at one station and of + 0·32 between birth weight and cow weight on the last weigh day prior to calving at the second station from which they drew their data. Dawson *et al.* (1947) examined the relative influences of weight of dam and age of dam on birth weight of the calf and found them to be approximately equally related to birth weight. The multiple correlation coefficient between both age and weight of dam with birth weight was 0·56, or very little higher than the respective simple correlations (r = ·45 and ·49).

(e) Time of Birth

The season of birth influences the birth weight of the calf indirectly through the nutritional plane of the dam. In most studies, the calving period is quite short, so this influence is minimized. Koch and Clark (1955) examined this effect with a calving period of two months and found that calves born later in the calving season were slightly heavier at birth. They attributed this difference to better pasture conditions or possibly to a weight difference caused by variation in gestation lengths of cows. J. W. Riley, of the Queensland Department of Agriculture and Stock (unpublished data 1959), has demonstrated the important influence of adverse maternal nutrition in depressing the birth weight of the calf. Davenport and Neil (1958) found only a slight difference between the birth weights of calves born in February–March and those born in May. The difference between the uncorrected birth weights of the calves in the two groups was 3 lb in favour of the calves born in May.

IV. RESULTS AND DISCUSSION

The uncorrected average birth weights of the calves in the four years of this study were 71·6, 70·2, 74·1 and 65·3 lb (Table 1). When a correction was applied for age of dam and sex, the overall mean birth weight was 70·4 lb. This is one of the same order as the birth weights of Hereford calves reported in the literature. Dawson *et al.* (1947) recorded an overall average of 70·1 lb for Hereford calves. Nelms and Bogart (1956) reported mean birth weights for three lines of Hereford cattle of 65–73 lb. Koch and Clark (1955) reported an overall mean of 75·6 lb and Clark *et al.* (1958) an average birth weight of 76 lb.

(a) Sex

The sex difference of 4·7 lb in favour of the male calves, after correcting for age of dam, was significant at the 1 per cent. level. This sex difference is of similar order to those reported in the literature. Some attempts have been made to explain the reason for this sex difference. Knapp *et al.* (1940) considered that differences in length of gestation period account for 25–35 per cent. of the variation in birth weight between sexes. Dawson *et al.* (1947) found that the gestation length of male calves was slightly longer than that of female calves.

(b) Year Differences

The year differences were significant at the 1 per cent. level. An examination of the average birth weights within years indicates that there was little change in the average birth weight during the first three years, but during the fourth year there was a marked difference, the average for the calves born in

Table 1

MEAN UNCORRECTED BIRTH WEIGHTS OF THE CALVES, AGES OF DAMS AT CALVING AND WEIGHTS OF THE DAMS IN THE MONTH OF MAY PRIOR TO CALVING

	Year				
	1954	1955	1956	1957	All Years
Average birth weight (lb)—					
Males	73·5	73·4	76·0	67·6	72·8
Females	66·9	66·0	72·0	62·7	67·4
All calves	71·6	70·2	74·1	65·3	70·4
Age of dam at calving (year) ..	4·8	5·5	6·1	5·9	5·6
Weight of dam in the May prior to calving (lb)	878	944	948	842	909
Rainfall (in.)	38·07	36·05	55·84	9·11	..

the 1957 calving season being 5·1 lb less than the overall mean. This was due to 1957 being a drought year, when the pregnant cows were on an extremely low plane of nutrition (Table 1). This is in agreement with results reported by Knapp *et al.* (1942), Burris and Blunn (1952), and Clark *et al.* (1958), who found

that birth weight varied relatively little from year to year except following drought. However, while the birth weights of the calves varied from year to year, the effect of the various other factors influencing birth weight did not differ between years.

(c) Age of Dam

Because of the small number of animals involved in this study (Table 2) and because a search of the literature revealed that only calves from first-calf heifers had significantly lower birth weights than calves from mature cows, the only comparison made was between first-calf heifers and mature cows. In this herd, the heifers were mated at about two years so that they were approximately

Table 2

Distribution of Calves of Both Sexes from Cows of Each Age Group Within Each Year

Year	Sex	No. of Calves for Each Category of Age of Dam in Years							
		3	4	5	6	7	8	9	10
1954	Male	5	34	13	4	7	..	..	..
	Female	2	31	15	5	8	2	1	..
1955	Male	6	5	36	15	5	10	1	..
	Female	11	0	28	17	6	7	3	1
1956	Male	11	7	2	27	17	3	8	2
	Female	7	6	3	26	14	5	6	..
1957	Male	13	5	7	2	27	5	3	2
	Female	12	10	3	1	16	10	2	1

three years old when they calved. This may account to some extent for the lack of significance in the difference of 4·03 lb between the birth weights recorded from cows of the two classes (Table 3). The relationship between birth weight and age of dam within years is presented graphically in Figure 1.

Table 3

Estimates of the Mean Birth Weights of All Calves and the Effects of the Factors Considered with their 95 per cent. Confidence Limits

—	Effect	95% Confidence Limits
Mean birth weight of all calves (corrected for age of dam) (lb) ..	70·1 ± 9·6*	
Sex effect (male-female) (lb) ..	4·66	2·59 to 6·73
Age of dam effect (adult-first calf) (lb)	4·03	−0·36 to 8·42
Weaning age (days)	182 ± 17·5*	

* Standard deviation.

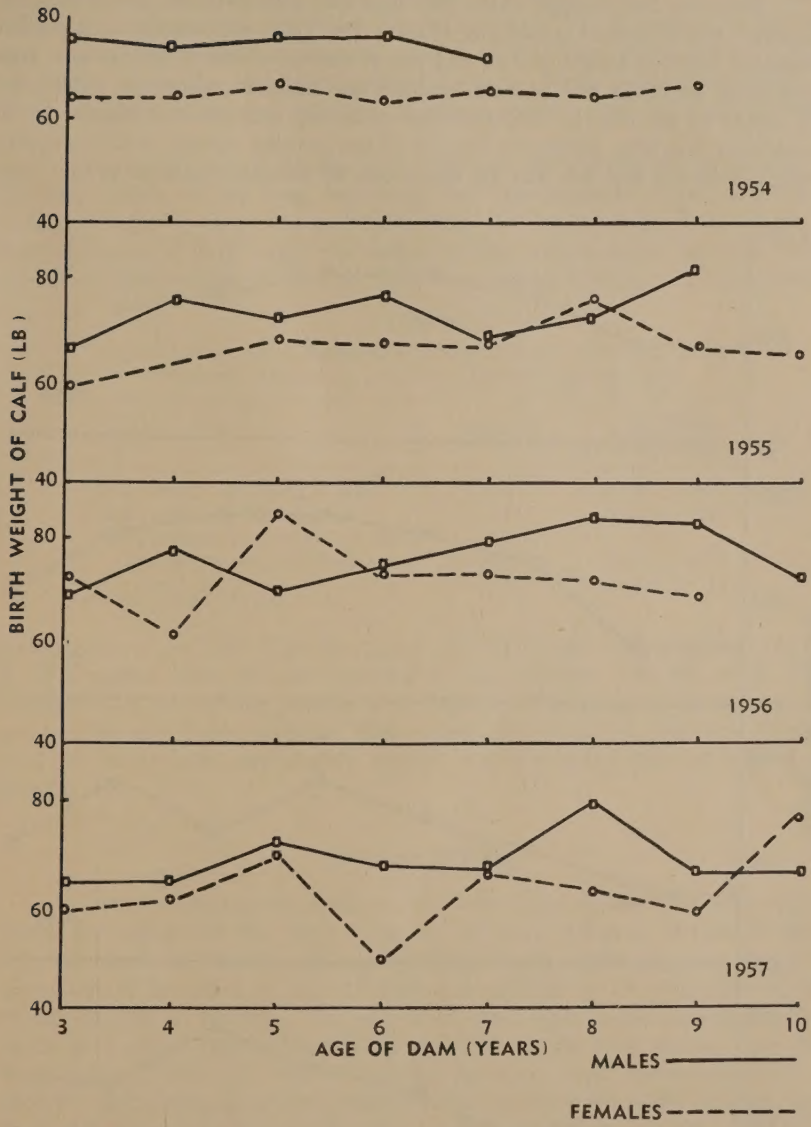

Fig. 1.—Birth weights of calves from each age group of cows in each year.

(d) Weight of Dam

Since the body weight of the dam is closely related to the age of the dam, this aspect was examined graphically (Figure 2). There appeared to be a positive association between weight of dam and age of dam up till nine years of age, after which there were too few animals to draw any definite conclusions (Table 2). The weight of the cow in May previous to calving was selected because it has been shown that May represents the end of the growing season on this property. It was considered that this was the time when all animals would be in uniformly

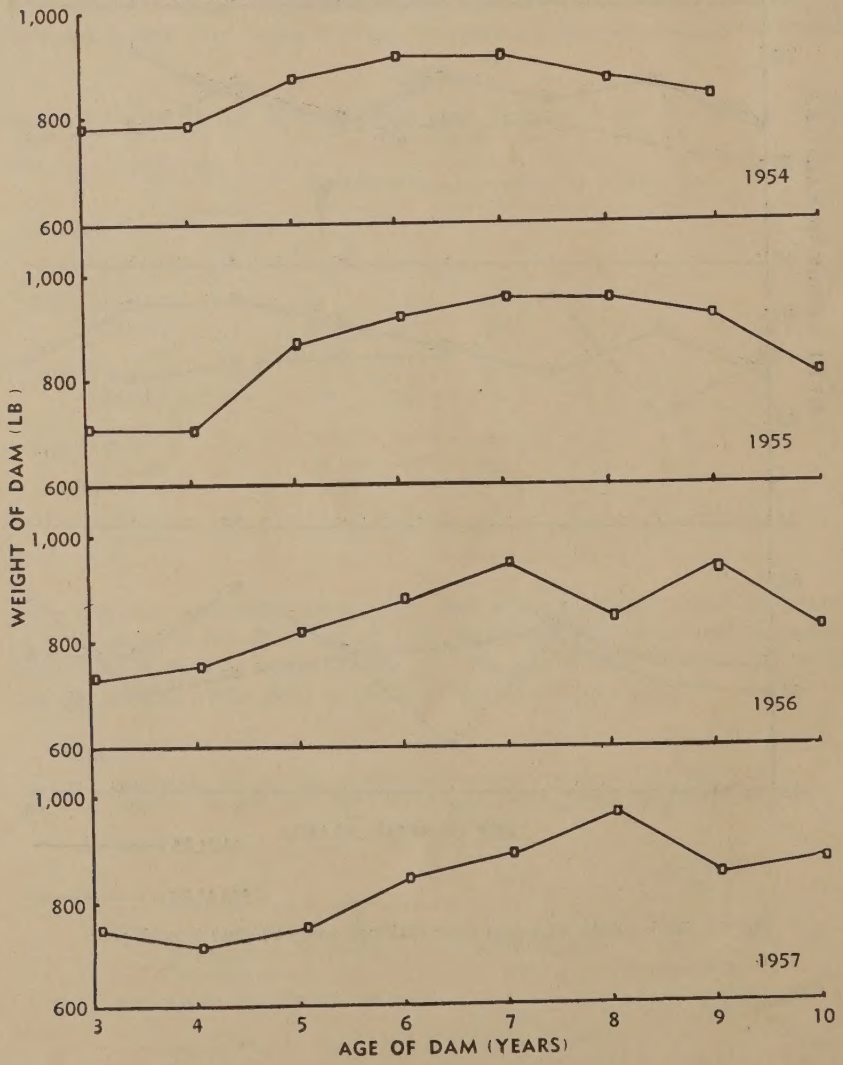

Fig. 2.—Average weights of cows at various ages in each year.

good condition, pregnant cows being not more than four months advanced in pregnancy and lactating cows having sufficient pasture to meet the demands of their calves and maintain condition. The May weight was as close an approximation as possible of the characteristic weight of the dam, which Mason (1951) considered to be the important factor influencing birth weight rather than the cow's condition or state of nutrition, as demonstrated in the 1957–58 calving.

A correlation of 0·24 was found between the birth weight of the calf and the May weight of the dam, indicating that approximately 6 per cent. of the variation in birth weight was associated with the weight of the dam (Table 4). The regression of birth weight on weight of dam indicated that for each 100 lb increase in body-weight of the dam there was a corresponding 1·9 lb increase in

Table 4

CORRELATION AND REGRESSION CO–EFFICIENTS BETWEEN BIRTH WEIGHT, WEIGHT OF DAM AND WEANING AGE OF CALF

—	Correlation Coefficient	Regression Coefficient and Standard Error
Birth weight on Weight of dam ..	0·24**	0·019 ± 0·005
Birth weight on Weaning age ..	−0·18**	−0·096 ± 0·034
Birth weight on Weight of dam (weaning age held constant) ..	+0·26**	0·021 ± 0·005

** Significant at the 1 per cent. level.

birth weight of the calf. This association of birth weight with weight of the dam is of a similar order to that reported in the literature (Knapp *et al.* 1942; Gregory *et al.* 1950; and Dawson *et al.* 1947). When time of calving was held constant the correlation between birth weight and weight of dam was increased to 0·26, which was only slightly greater than that when time of calving was ignored.

(e) Time of Birth

Since the calving occurred over a short period of less than three months it was not anticipated that there would be any large influence of time of calving on birth weight of the calf. At weaning time, all the calves were weaned on the same day, so the effect of time of birth was studied by the regression of birth weight on age at weaning. This regression was negative and significant, which meant that calves born towards the end of the period were heavier than those born earlier (Table 4). On the average the birth weight increased ·96 lb for each 10 days during the calving season. Thus over the 10 weeks' calving period there was an overall average increase in birth weight of 6·7 lb. This effect, however, was only slight, as indicated by the size of the correlation coefficient ($r = 0·18$) between birth weight and weaning age. Only 3 per cent. of the variation in birth weight was due to time of calving, compared with 6 per cent. for weight of dam. The slight improvement in the correlation between weight of dam and birth weight when time of calving was held constant indicates that there was little association between body-weight of the cow and the time of calving.

(f) Repeatability

Repeatability of traits can be defined as the proportion of the variance among cows each with one record which is due to permanent differences among the cows. It can also be regarded as the correlation between repeated records by the same individual. Repeatability is needed when comparing the producing abilities of animals which have different numbers of records. Traits such as birth weight occur only once in an animal's lifetime and are repeatable only when considered as a characteristic of the cow. Since a cow influences the calf both by the genes transmitted and by the maternal environment she provides from birth to weaning, the correlation between calves from the same cow includes a component due to genetic likeness of half-sibs, a component from the maternal environment, and any gene-environment interactions. Thus the repeatability may be regarded as an upper limit for the heritability of the trait. In this analysis, sire effects have been ignored, and it is reasonable to expect that sire differences would have a bearing since sire influences have been reported in the literature (Dawson *et al.* 1947; Eckles 1919; and Knapp and Nordskog 1946).

The repeatabilities or intra-class correlations are shown in Table 5. The repeatabilities of birth weight and weight of dam are significant at the 1 per cent. level while that of weaning age is just significant at the 5 per cent. level. Of these, the repeatability of weight of dam is of a sufficient order to be useful. It would indicate that selection of dams for body weight could be quite effective. However, the repeatability of birth weight is not sufficiently large to suggest that the prediction of the birth weight of a calf from a certain cow would be accurate.

Table 5

REPEATABILITY (INTRA-CLASS CORRELATION) OF THE BIRTH WEIGHT, WEANING AGE AND WEIGHT OF THE COW

—	Repeatability	95% Confidence Limits
Birth weight	0·25**	0·12 to 0·36
Weaning age	0·13*	0·00 to 0·25
Weight of dam	0·86**	0·83 to 0·89

* Significant at the 5 per cent. level.
** Significant at the 1 per cent. level.

V. CONCLUSIONS

In general, it can be seen that the birth weight of calves is influenced by both genetic and environmental influences. Certain of the environmental influences have been assessed and some have been found to have a fairly large influence on the birth weight of the calf. The repeatability of birth weight has been determined in order to obtain some indication of the possible genetic influences on the birth weight of the calf. These would appear to be rather low and of a similar order to those recorded in the literature. The calculation of repeatability ignoring sire effects was resorted to rather than heritability since less than half of the herd is mated in single-bull mating paddocks in any one year. The determination of heritability would mean the discarding of over half the data and the consequent low numbers used would not give reliable heritability estimates.

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(Received for publication February 25, 1960)

OBSERVATIONS ON THE UTILIZATION BY CATTLE OF *AXONOPUS AFFINIS* FOLLOWING FOLIAR APPLICATION OF UREA, MOLASSES AND MONOSODIUM PHOSPHATE

By M. S. O'BRYAN*

SUMMARY

A supplement containing urea, molasses, monosodium phosphate and cobalt chloride was supplied in strips at weekly intervals to a mature carpet grass (Axonopus affinis) pasture in south-eastern Queensland during the autumn-winter months of 1958 and 1959.

In the period April to August 1958, Hereford heifers maintained weight on the treated pasture, but in the same period of 1959 lost considerable weight. There was no significant difference in body-weight between animals in the control and treated paddocks in either year.

In 1958 the total pasture available was moderately low in crude protein (5-7 per cent.) but in both groups the animals selected pasture containing 10-12 per cent. protein. In 1959 the protein content ranged from 3·5 to 5 per cent. and both groups selected pasture containing 8-10 per cent. protein. It is suggested that failure to gain weight was due to a low feed intake together with a high energy expenditure in selecting this diet.

In both experiments stock showed a marked preference for the treated strips immediately after spraying. This preference was not evident 24 hours after treatment.

Failure to obtain a response in body-weight in cattle from the foliar application of urea and molasses to mature carpet grass is attributed to the high degree of selectivity of grazing and the interval between treatments, together with the short-term response in palatability in this environment.

I. INTRODUCTION

Paspalum (*Paspalum dilatatum* Poir.) pastures established in the high-rainfall areas of south-eastern Queensland have, in recent years, been seriously invaded by narrow-leaf carpet grass (*Axonopus affinis* Chase). Growth of these pastures is related to temperature and rainfall, and in this area effective rainfall is usually limited to the summer months. In most years there is an abundant growth of pasture from November to April. Analytical records of the Queensland Department of Agriculture and Stock show that the protein, phosphate and energy values of mature carpet grass pastures are below the levels required for maintenance of adult cattle.

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A beef cattle property 60 miles north of Brisbane was selected as a site for examining the effect of urea/molasses/phosphate supplements on the growth rate of cattle under grazing conditions. Previous investigations conducted on this property by Chester, Marriott, and Harvey (1957) suggested that failure to eat the mature carpet grass pasture is an important cause of the pronounced weight loss in animals during winter and early spring. Evidence of phosphate, copper and cobalt deficiency was also recorded by these workers.

Beames (1960) and Morris (1958) showed that the addition of urea markedly increased the feed intake of low quality pasture hay and prevented weight loss in cattle. The former worker fed a urea/molasses supplement to stalled animals, while Morris fed urea and grain sorghum mixed with pasture hay to cattle on a group basis.

The spraying of dry veldt pasture with urea and molasses has been practised extensively in South Africa (Kellermann and Groenewald 1956). Findings quoted by Tribe and Coombe (1958) indicate that dry veldt pasture sprayed with urea and molasses allowed the grazing animals to maintain body-weight, due to an improvement in both palatability and nutritive value of the grazing.

The experiments reported in this paper were made during the autumn and winter of the years 1958 and 1959.

II. METHODS AND MATERIALS

(a) Experimental Paddocks

An area of approximately 8 acres of relatively uniform river flats with a predominantly carpet grass pasture was fenced and subdivided into two comparable 4-acre paddocks.

In the 1958 experiment both paddocks were unstocked from March 11, 1958, to April 29, 1958, to ensure a good body of mature carpet grass. On April 29 both paddocks were stocked at the rate of two animals per acre and thereafter Paddock 1 was sprayed in strips at weekly intervals for the 16 weeks of the experiment.

For the 1959 experiment the area was unstocked from August 19, 1958, to March 12, 1959, when both paddocks were again stocked at the rate of two animals per acre. Commencing on March 20, Paddock 1 was sprayed in strips at weekly intervals for the 26 weeks of the experiment.

(b) Experimental Animals

In 1958, 16 Hereford heifers 16–20 months of age were available. Two groups of eight heifers were selected by stratified random allocation on a body-weight basis. In 1959, 24 Hereford heifers 9–12 months of age were available. Two groups of eight heifers were selected by stratified random allocation on a body-weight basis.

The possible complication of copper deficiency was avoided by the intravenous injection of copper sulphate to all experimental animals one week prior to the commencement of each experiment.

In both experiments all animals were sprayed with diazinon plus DDT for tick (*Boophilus microplus*) control and drenched with phenothiazine for worm control at the commencement and thereafter at 28-day intervals. In 1958 the tick population was negligible for the last 12 weeks of the experiment and in 1959 for the last 18 weeks.

(c) Body-weight

This was determined initially and at 28-day intervals using a weighbridge. A standard procedure was adopted. The experimental animals were driven into small bare holding yards at 8.30 a.m.; weighing commenced at 10 a.m. and was completed by 10.30 a.m.

(d) Pasture

In 1958 line transects to determine pasture composition were made in each paddock in April prior to the commencement of the experiment and again in August at its conclusion. In 1959 line transects were made six weeks prior to the commencement of the experiment, at its commencement in March, in July and again in October one week after its conclusion.

Pasture yield was determined from quadrats cut in each paddock to a height of approximately 2 in. above ground level. Pre-experimental yield measurements on April 15, 1958, and March 20, 1959, were representative of total pasture in both treated and control paddocks. Subsequent measurements at 28-day intervals were representative of the strip just prior to spraying for the treated paddock and of a similar strip located in the adjacent control paddock. Pasture samples taken in this manner were analysed for nutritive value.

(e) Pasture Spraying

In the 1958 experiment the material* used contained 78 per cent. molasses, 12·5 per cent. urea, 4·4 per cent. monosodium phosphate and 0·005 per cent. cobalt chloride, the balance being added water. Just prior to use the material was diluted with twice its volume of water. Spraying was carried out with a boom spray fitted to a motor vehicle. The sediment of calcium phosphate which resulted from the addition of river water to the supplement necessitated the use of Rega No. 1 nozzles in the spray line and constant stirring during spraying. A spray pump, operating at 200 lb pressure and driven by a 1.25 h.p. motor, was used

* This material was supplied by William Cooper and Nephews (Australia) Pty. Ltd. under the trade name "Fos-U-Mol".

Initially 0·25 ac strips were sprayed at weekly intervals with 42 lb of the proprietary material. This rate was provided to offer each animal the equivalent of 0·75 lb of the product daily. From the seventh week the area of the treated strip was reduced to 0·16 ac, to see if this restriction would induce overgrazing of the treated strips.

In the 1959 experiment the material used contained 75 per cent. molasses, 18 per cent. urea, 4·4 per cent. monosodium phosphate and 0·005 per cent. cobalt chloride. The same equipment as used in 1958 was employed to spray 0·16 ac strips in Paddock 1 with 42 lb of this material at weekly intervals.

(f) Faecal Samples

Samples from freshly voided faeces were collected in each paddock at weekly intervals by the unpublished procedure of K. W. Moir, of the Queensland Department of Agriculture and Stock. This involved the collection of samples of about 20 g from each of a minimum of 10 fresh dung pads. The bulked samples from each paddock were analysed for protein, phosphorus, calcium and organic Matter. From the regressions developed by Moir, the protein, phosphorus and calcium levels were assessed in the pasture selected by the animals.

(g) Chemical Methods

The Official Methods of the Association of Agricultural Chemists (1955) were used in the analyses of pasture and faecal samples.

(h) Rainfall Data

Monthly rainfall data were obtained from the district official recording station located about five miles from the experimental paddocks.

III. RESULTS

Rainfall data are presented in Table 1 for the years 1953 to 1959. The year 1957 was unusually dry and effective summer rains did not occur until January 1958. This delayed the growth of pasture, so the amount of mature grass present at the commencement of the first experiment in April 1958 was less than in previous years. Good rains in April caused a prolonged period of pasture growth. Flooding of the paddocks resulted from unusually heavy rains in June. Good summer rains from December 1958 gave abundant mature grass at commencement of the second experiment in March 1959. Heavy rains in late March caused flooding and necessitated the withdrawal of stock from the experimental paddocks for one week. Late summer/autumn rains provided some green pick although the bulk of pasture was carpet grass at the standing hay stage of growth.

Table 1

MONTHLY RAINFALL (INCHES) RECORDED AT DISTRICT OFFICIAL RECORDING STATION

Month	1953	1954	1955	1956	1957	1958	1959
January	8·50	7·78	2·97	5·15	6·77	7·75	10·52
February	17·25	24·77	3·11	19·55	2·79	9·89	6·98
March	8·25	6·03	20·03	19·13	5·96	6·72 [1]	10·07 [4]
April	3·60	2·12	5·69	7·99	0·36	13·69 [2]	4·49
May	1·50	4·31	11·77	5·88	0·12	2·18	3·71
June	0·20	2·68	1·50	4·07	1·76	22·33	3·52
July	0·43	12·60	1·59	1·57	7·26	0·12	5·22
August	4·52	4·85	0·11	0·20	4·41	2·93 [3]	1·02
September	2·18	3·78	1·67	1·32	0·06	1·85	5·12 [5]
October	2·87	9·98	3·79	1·97	2·76	1·31	8·17
November	5·99	4·66	0·53	3·66	2·36	3·28	7·34
December	1·59	5·92	8·93	8·15	1·52	12·24	4·90
Totals—							
Apr.–Aug. ..	10·25	26·56	20·66	19·71	13·91	41·25	17·96
12 months ..	56·88	89·48	61·69	78·64	36·13	84·27	71·06

[1] Stock excluded from experimental paddocks on 18–iii–58.

[2] Commencement of first experiment on 29–iv–58.

[3] Conclusion of first experiment on 19–viii–58; stock excluded from experimental paddocks until 12–iii–59.

[4] Commencement of second experiment on 20–iii–59.

[5] Conclusion of second experiment on 29–ix–59.

The pasture composition from line transects in the two experimental paddocks is shown in Table 2. For both experimental paddocks in each year the

Table 2

PASTURE COMPOSITION IN EXPERIMENTAL PADDOCKS

(*Expressed as ground cover*)

Date	Experiment	Control Paddock		Treated Paddock	
		Axonopus affinis	*Paspalum dilatatum*	*Axonopus affinis*	*Paspalum dilatatum*
		Per cent.	Per cent.	Per cent.	Per cent.
9–iv–58	1	89·0	11·0	89·2	10·8
19–viii–58		90·9	9·1	90·7	9·3
6–ii–59	2	85·0	15·0	82·0	18·0
20–iii–59		86·0	14·0	85·0	15·0
3–vii–59		93·0	7·0	95·0	5·0
6–x–59		92·5	7·5	93·0	7·0

dominant pasture species was *Axonopus affinis*. *Paspalum dilatatum* was present in limited quantities.

Table 3

OVEN-DRY-MATTER YIELDS OF PASTURE AVAILABLE IN EXPERIMENTAL PADDOCKS

Date	Experiment	Control Paddock (lb per ac)	Treated Paddock (lb per ac)
15–iv–58	1	1,450	1,630
29–iv–58		1,940	2,300
27–v–58		1,450	2,180
24–vi–58		910	1,090
22–vii–58		730	910
19–viii–58		550	730
20–iii–59	2	3,270	3,630
14–iv–59		2,540	1,820
19–v–59		2,540	2,540
23–vi–59		1,450	2,540
11–viii–59		1,090	1,090
11–ix–59		1,450	1,090
6–x–59		360	360

Table 4

CHEMICAL COMPOSITION OF TOTAL PASTURE AVAILABLE TO STOCK IN EXPERIMENTAL PADDOCKS

(*Moisture-free basis*)

Date	Paddock	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)	Ash (%)	Lime (%CaO)	Phosphoric Acid ($\%P_2O_5$)
Experiment 1								
15–iv–58	Control ..	5·1	0·9	41·2	47·3	5·5	0·15	0·41
	Treated ..	4·9	0·6	41·5	47·5	5·5	0·18	0·40
29–iv–58	Control ..	6·4	0·9	29·9	55·3	7·5	0·22	0·29
	Treated ..	7·0	1·0	26·1	58·0	7·9	0·24	0·35
27–v–58	Control ..	6·7	1·1	32·9	51·4	7·9	0·22	0·34
	Treated ..	6·5	1·0	34·3	50·4	7·8	0·17	0·36
24–vi–58	Control ..	6·3	0·3	34·2	47·8	11·4	0·47	0·34
	Treated ..	7·0	0·3	31·9	47·7	13·1	0·39	0·40
22–vii–58	Control ..	5·7	0·6	29·6	48·7	15·4	0·41	0·34
	Treated ..	6·6	0·7	28·5	53·6	10·6	0·39	0·39
19–viii–58	Control ..	5·8	0·6	31·2	51·0	11·4	0·43	0·32
	Treated ..	6·9	0·7	28·9	51·8	11·7	0·54	0·33
Experiment 2								
20–iii–59	Control ..	4·7	1·0	40·3	46·5	7·5	0·12	0·32
	Treated ..	3·9	0·9	39·1	49·9	6·2	0·16	0·41
14–iv–59	Control ..	3·5	0·8	41·6	47·2	6·9	0·13	0·20
	Treated ..	4·7	0·8	39·0	48·9	6·6	0·14	0·25
19–v–59	Control ..	4·5	1·2	39·2	45·7	9·4	0·46	0·29
	Treated ..	4·4	1·4	37·8	48·2	8·2	0·33	0·22
23–vi–59	Control ..	3·8	0·8	39·3	47·8	8·3	0·39	0·22
	Treated ..	4·3	0·7	37·4	49·2	8·4	0·37	0·27
11–viii–59	Control ..	4·6	1·2	37·6	49·2	7·4	0·35	0·22
	Treated ..	4·8	1·2	33·9	52·0	8·1	0·30	0·22
11–ix–59	Control ..	4·2	1·1	39·2	47·7	7·8	0·45	0·19
	Treated ..	5·0	1·1	35·7	49·7	8·5	0·39	0·23
6–x–59	Control ..	6·1	0·9	35·5	48·1	4·4	0·36	0·26
	Treated ..	6·1	1·0	34·8	49·9	8·2	0·40	0·29

The oven-dry-matter yields of pasture available in each paddock at six sampling periods in 1958 and seven sampling periods in 1959 are recorded in Table 3. A higher yield of pasture is apparent in 1959. This is attributed to the better rainfall in the summer of 1958–59 together with the longer period in which the experimental paddocks were unstocked prior to the 1959 experiment.

The chemical composition of pasture samples collected for yield measurements is shown in Table 4. All samples are representative of total pasture available to stock from a height of 2 in. above ground level. They tend to be low in protein and high in fibre. The protein and phosphoric acid contents are lower in Experiment 2. This is in agreement with yield measurements, which showed a greater bulk of mature pasture in 1959. The higher ash content recorded from June 24, 1958, in Experiment 1 and from May 19, 1959, in Experiment 2 resulted from contamination of the pasture with soil following flooding of the paddocks.

In each paddock the chemical composition of the diet selected was assessed from analyses of representative faecal samples. Values are shown in Table 5. It

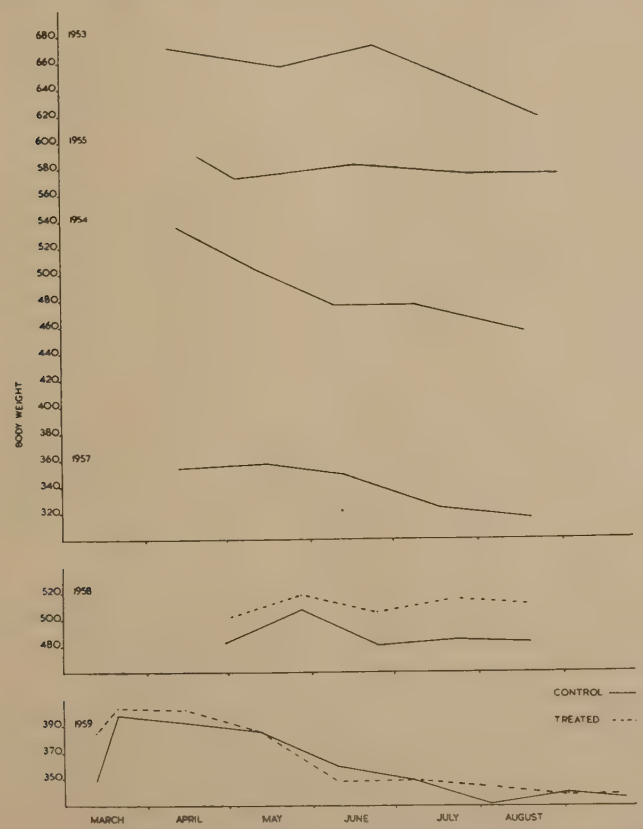

Fig. 1.—Changes in body-weight in Hereford heifers during autumn-winter

is apparent that the composition of the diet selected was much better than that indicated from analysis of total feed available. It is also apparent that the diet selected in Experiment 2 (1959) was much lower in protein and phosphoric acid than that selected in Experiment 1 (1958). These findings are in keeping with the body-weight records of experimental animals.

Table 5

CHEMICAL COMPOSITION OF PASTURE SELECTED BY STOCK IN EXPERIMENTAL PADDOCKS

(*Moisture-free basis*)

Date	Control Paddocks			Treated Paddock		
	Protein (%)	Lime (%CaO)	Phosphoric Acid ($\%P_2O_5$)	Protein (%)	Lime (%CaO)	Phosphoric Acid ($\%P_2O_5$)
Experiment 1—						
13–v–58	10·9	0·32	0·43	10·8	0·32	0·45
20–v–58	11·5	0·34	0·49	10·8	0·31	0·45
27–v–58	10·8	0·32	0·45	11·2	0·32	0·45
3–vi–58 ..	9·7	0·37	0·45	10·5	0·34	0·43
17–vi–58	10·8	0·32	0·33	10·9	0·32	0·35
24–vi–58	10·3	0·34	0·43	10·7	0·34	0·45
1–vii–58 ..	10·5	0·31	0·43	10·4	0·36	0·43
8–vii–58 ..	11·1	0·37	0·45	10·3	0·34	0·40
15–vii–58 ..	11·7	0·36	0·47	10·3	0·34	0·43
22–vii–58 ..	12·0	0·36	0·45	11·1	0·34	0·43
29–vii–58 ..	11·6	0·36	0·43	11·0	0·36	0·45
5–viii–58 ..	10·4	0·33	0·40	10·3	0·34	0·43
12–viii–58 ..	9·5	0·33	0·38	9·7	0·36	0·40
19–viii–58 ..	10·8	0·33	0·40	9·5	0·34	0·45
Experiment 2—						
26–iii–59	7·8	0·19	0·20	8·2	0·17	0·18
7–iv–59	7·5	0·18	0·20	8·0	0·17	0·21
14–iv–59	9·3	0·17	0·21	9·3	0·17	0·22
21–iv–59	7·7	0·19	0·21	9·5	0·18	0·21
28–iv–59	8·4	0·14	0·23	8·7	0·18	0·25
5–v–59	8·5	0·17	0·21	8·7	0·17	0·23
12–v–59	9·5	0·13	0·22	8·6	0·14	0·23
19–v–59	8·6	0·12	0·26	8·7	0·14	0·26
26–v–59	7·8	0·20	0·23	8·5	0·20	0·23
2–vi–59	8·5	0·19	0·25	8·7	0·20	0·25
9–vi–59	7·8	0·16	0·23	8·0	0·16	0·21
23–vi–59	9·5	0·21	0·25	8·5	0·17	0·25
30–vi–59	9·1	0·17	0·23	9·1	0·21	0·23
8–vii–59 ..	8·7	0·20	0·23	8·9	0·19	0·23
14–vii–59 ..	8·7	0·22	0·28	8·5	0·21	0·23
28–vii–59 ..	8·4	0·21	0·28	8·3	0·20	0·23
4–viii–59 ..	8·4	0·20	0·28	8·5	0·19	0·22
11–viii–59 ..	10·5	0·20	0·25	8·5	0·19	0·27
18–viii–59 ..	8·8	0·18	0·20	8·0	0·19	0·20
8–ix–59	10·2	0·19	0·22	7·6	0·14	0·18
15–ix–59	9·6	0·19	0·23	9·7	0·18	0·23
22–ix–59	10·5	0·20	0·23	10·0	0·19	0·24

Mean body-weight changes in experimental animals are shown in Figure 1. Body-weight data are included for non-pregnant Hereford heifers on this property from April to August in the years 1953, 1954, 1955 and 1957. Of the years for which records are available on the property, it was only during 1958 that weight losses did not occur during autumn/winter. There were no significant differences in body-weight between cattle in the control and treated paddocks either in 1958 or in 1959.

IV. DISCUSSION

Urea has been used extensively as a source of nitrogen which can be converted to bacterial protein in the rumen. It has the advantage that the cost per unit of nitrogen is low compared with that of protein concentrates. Disadvantages, related to its high toxicity unless consumed slowly, are overcome by its inclusion in bulky feeds which ensure a slow intake by the animal. Theoretically, its use with molasses and phosphate as a pasture spray could provide nutrients known to be deficient in mature *Axonopus affinis* pastures in Queensland and prevent the fall in production in grazing animals during the winter months.

The property selected for these observations was that described by Chester, Marriott, and Harvey (1957). A number of factors influenced this selection. The area is typical of much of south-eastern coastal Queensland. Studies on pasture and on growth rate of Hereford heifers since 1953 are available. In all years there has been an abundance of pasture at the standing hay stage in April. The predominant pasture species is *Axonopus affinis,* which is not eaten readily by stock at the standing hay stage and is low in protein, phosphoric acid and metabolizable energy. This pasture provides a complete ground cover, which is desirable to minimize losses in pasture spraying. Body-weight records show that in the years 1953 to 1957 all animals lost weight during the winter months.

The rate of application of the molasses/urea/phosphate mixture allowed 0·75 lb, equivalent to 1.5 oz urea in 1958 and 2·1 oz urea in 1959, per head per day. Tribe and Coombe (1958) stated that the amount of urea for yearling cattle should not exceed 2 oz per head per day.

The cattle showed marked preference for the sprayed strip. However, the preference did not persist for more than two days and at no time were the sprayed strips eaten bare in the manner reported by Tribe and Coombe (1958).

Total pasture available to stock in the experimental paddocks was low in protein in 1958 and considerably lower in protein and phosphoric acid and considerably higher in fibre in 1959. Pasture of this composition fed to animals under pen or stall conditions would not be expected to maintain body-weight.

Application of the technique of Moir, who developed regressions relating faecal composition to pasture composition, indicates that the experimental animals were able to select a production diet in 1958 and a diet better than maintenance in 1959. Failure to gain weight could be a function of a low feed intake together with high energy expenditure in selecting this diet. The former was suggested also by Chester, Marriott, and Harvey (1957).

The chemical composition of the selected diet in terms of protein and phosphorus was higher in 1958 than in 1959. This is reflected in body-weight. In 1958, experimental animals mantained body-weight from April to August, whereas in 1959 all animals showed a considerable loss in weight during this period.

Under seasonal conditions pertaining in the autumn/winter of 1958, experimental animals in the control paddock were selecting a diet containing approximately 11 per cent. protein. In the treated paddock, urea was added to lift the protein equivalent of the total pasture available from about 6 per cent. to approximately 11 per cent. In 1959 the experimental animals in the control paddock were selecting a diet containing approximately 8·5 per cent. protein. In the treated paddock urea was added to lift the protein equivalent of the total pasture available from about 4 per cent. to approximately 8·5 per cent. Faecal analyses and body-weight data support the conclusion that in both experiments the intake and composition of the selected diets were similar for both treated and control groups.

The findings of South African workers, referred to by Tribe and Coombe (1958), indicate that the spraying of veldt pasture with urea and molasses allows grazing cattle to at least maintain body-weight. Thus in 1958 failure to get a measurable response in body-weight in animals in the treated paddock may be related to the unusual seasonal conditions in this locality, which resulted in all animals being able to select a diet of sufficient quality and quantity to maintain weight. However, the season in 1959 was comparable with previous years for which data are included, and body-weight losses from April to August averaged approximately 60 lb per head in both the treated and the control areas. From 1959 data two conclusions are drawn:—

(1) In the control paddock experimental animals were unable to select sufficient pasture of the quality necessary to maintain body-weight.

(2) In the treated paddock pasture spraying with urea, molasses, phosphate and cobalt chloride did not improve the overall quality and quantity of pasture consumed.

Failure to get a weight response in grazing cattle from the foliar application of urea, molasses, phosphate and cobalt to a predominantly carpet grass pasture under Queensland conditions may be due to a number of factors. These include the frequency of treatment (weekly in both experiments), the heavy

dews which are a feature of this locality, the intermittent rainfall during the experimental period, the known low palatability to cattle of mature carpet grass and the high degree of selective grazing by cattle on these pastures. It is considered that more frequent treatments would be uneconomical and impracticable under Queensland conditions. It is possible that a response from such treatment might result on pastures which would not permit the same degree of selective grazing. However, in the light of present knowledge it is suggested that in Queensland an economic response from urea and molasses can only be anticipated when these are used as a supplement to cattle fed low quality pasture hay under pen conditions as described by Beames (1960) and Morris (1958).

V. ACKNOWLEDGEMENTS

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AN APPARATUS FOR RECORDING MILK-FLOW CURVES OF COWS MILKED BY MACHINES

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SUMMARY

The apparatus records the speed of milking graphically through low voltage electrical impulses. Each 0·2 lb milk entering the vacuum milk bucket is registered as an increment on the graph. All necessary data for the assessment and comparison of milking rates can be obtained from the milk-flow curves.

The apparatus is portable, may be used in any bail, and may be fitted to any commercial milking plant, thus enabling recordings to be made of the milking rates of cows in commercial herds.

I. INTRODUCTION

Research workers in several countries have carried out experiments to obtain information about the mechanical milking of cows. In many of these experiments concerning milking rate, the data were obtained by suspending a bucket from a balance and, using a stop-watch, noting the amount of milk registered by the scales at intervals of 10, 20 or 30 seconds (Smith and Petersen 1946; Baxter, Clarke, Dodd, and Foot 1950; Dodd 1953; and Stewart, Schultz, and Coker 1957). This method would appear to be very laborious, and easily subject to human error. To achieve an accurate assessment of rates of milking, any means used should be capable of measuring small variations in the milking speed. It is desirable to have a complete record of milk ejection and this can be obtained only by having some recording device which gives a graph of the milk flow.

Several reports have been made of apparatus designed to give a graphic record of the milking process. Whittlestone (1945) described apparatus for the measurement of milking rate, and this equipment was later modified to make it completely automatic (Whittlestone and Phillips 1953). This apparatus was relatively complex and designed for use attached to special milking equipment in a research institute. Beck, Pryer, and Roark (1951) also used mechanical apparatus for recording rate of milk flow. In this case a copper wire was attached to the end of a suspension-coil spring, on which was hung the milking bucket, and to a pen assembly mounted on a continuous-feed kymograph. The complete apparatus was set up in the bails. A somewhat similar piece of apparatus was used by Ace, Theole, Kesler, and Cloniger (1959).

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A description is given here of a recording device which has been used in Queensland in measuring the milking rate of dairy cows. This apparatus is portable and designed for operation in conjunction with any type of commercial milking equipment.

II. DESCRIPTION OF THE APPARATUS

The two sections of the milk flow recording apparatus can be described as (1) the weighing and signalling system, and (2) the graphing unit. The former is set up in the bails beside the cow, and the graphing device may be placed in any convenient position within the milking shed, so the operator can be positioned away from the bails with no danger of causing unaccustomed disturbance to the cows.

Fig. 1.—The weighing and signalling section of the recorder set up in the bails.

(a) Weighing and Signalling System

This section of the recorder is shown in Figure 1. A vacuum bucket suspended from spring-type weighing scales is set up within a metal tripod stand. This stand has screw adjustments on each leg which enable the weighing bucket and frame to be positioned in a vertical plane irrespective of the slope of the bail floor. Rods, operating through ball-bearing guides at the top and bottom of the frame, prevent sideways movements of the bucket, which would affect the accuracy of the recording.

The lid is fitted with two taps and two $\frac{5}{8}$ in. metal tubes, so arranged internally as to enable milk to be completely emptied from the bucket into the main milk-line of the milking plant after each recording. The milk intake line is designed to minimize vibration of the bucket and frothing of the milk during filling by directing the flow of milk down the sides of the bucket. Any remaining vertical vibrations, which would cause undue oscillation of the arm of the signalling device, are dampened by a saucer-shaped, adjustable disc attached to the base of the bucket frame and operating in oil. Premium multi-grade oil, which maintains approximately constant viscosity at different air temperatures, is used. Flexible plastic tubes connect the metal tubes on the lid of the bucket to the main air-line and milk-line of the milking machine.

Milk from the teat assembly of the machine passes through a milk-flow indicator before entering the bucket. When the rate of milk flow is greater than 1 lb per min the sight-glass is full, but when the milk flow becomes less than this rate the level of milk in the sight glass falls. Machine stripping of cows was carried out when the milk in the sight-glass of the milk-flow indicator showed it to be half-full.

A special vacuum control valve enables any lower milking vacuum to be maintained in the test unit during controlled milking experiments without affecting the vacuum level of the remaining milking units of the machine. Vacuum is registered on a gauge fitted in the lid of the milk weighing bucket. A commercial pneumatic pulsator, operating directly from the control valve, and plain synthetic inflations with cluster-type milking claw are used. Another vacuum gauge mounted on the tripod stand can be connected by a plastic tube and metal T-piece to a milk claw rubber, to enable vacuum levels in the claw rubbers to be noted during the milking process.

The signalling device is attached to the face of the weighing scales and has a moving contact arm actuated directly by movement of the centre spindle of the scales. A series of 100 equidistant contact points are arranged in the form of a circle so that the contact arm moves from one point to the next around the circle as the weight of milk in the bucket increases. Each increment of 0·2 lb milk causes the arm to make contact with the next point. Alternate points are connected by electrical wiring, giving two distinct circuits in the signalling unit, such that each point is in a different circuit to the point on each

side of it. The electrical circuits are completed by attaching the positive terminal of a 6 v. battery to the centre movable contact arm, and connecting the lead wires from the two circuits in the signalling unit to negative through the recording unit. A standard 3-wire electrical lead is used to complete the circuit between the signalling unit and the graphing unit.

(b) Graphing Unit

This unit is illustrated in Figure 2. It is contained in a cabinet 15 in. x 15 in. x 8 in. and includes a drum which is operated by clockwork and which carries the graph paper around its circumference. The drum rotates at a constant speed of approximately one revolution per hour. Stopping and starting the clockwork is carried out by a manually operated lever. The upward movement of the recording arm and nib in contact with the paper rotating with the drum results in a milk-flow curve being drawn.

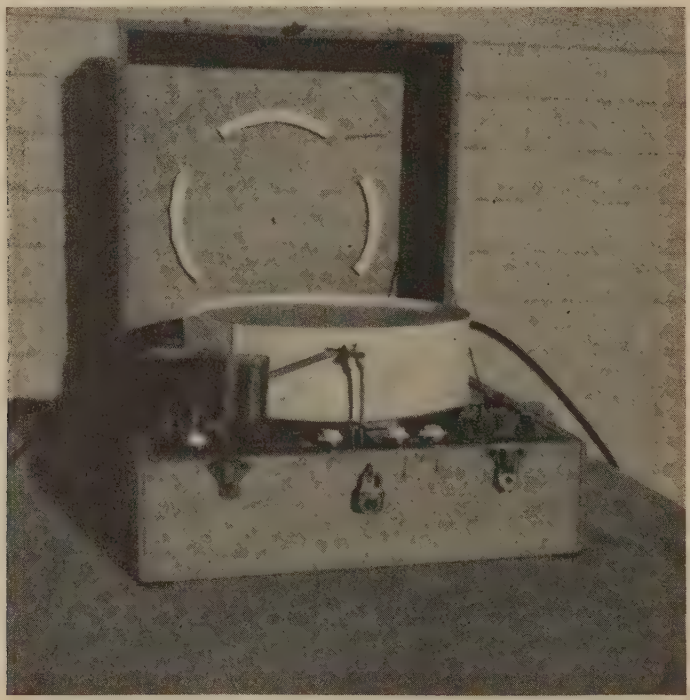

Fig. 2.—The graphing unit of the recorder.

Electrical impulses from the signalling unit, as the contact arm completes the circuit associated with each alternate set of points, momentarily energize relays in the graphing unit. The relays in turn cause an electromagnet to operate a catch-and-release trip which directly controls the constant upward movement of the recording arm through a train of spring-loaded cogs.

An electrically operated circuit breaker is used to break the flow of electricity automatically immediately the circuit is closed by the contact of the moveable contact arm with any contact point. This immediate breaking of the circuit prevents pitting or burning of the points in the signalling unit. The flow of electricity required to operate the automatic circuit breaker is sufficient to energize the electromagnet which controls the movement of the recording arm.

Indicator lights on both the weighing and the recording sections of the apparatus ensure that the weighing unit is at zero before the commencement of each cow's recording. Provision is made for manually controlled, electrically operated notations to be made on the milk-flow curves to indicate when the teat assembly is placed on the cow, the commencement of machine stripping and the time the cups are removed from the cow.

III. INTERPRETATION OF MILK-FLOW GRAPHS

Typical examples of the graphs obtained are shown in Figure 3. Curve A is a recording of a cow which milked out quickly and Curve B is that of a slower milker under the same conditions. The small arrows indicate the time of machine stripping.

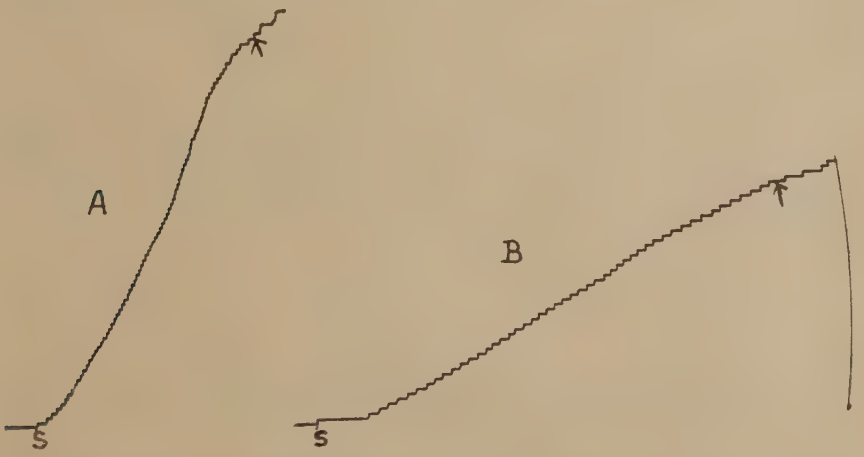

Fig. 3.—Typical milk-flow curves of a fast cow (A) and a slower cow (B) under the same milking conditions. S indicates the start of milking and the arrow machine stripping.

A plastic guide, calibrated with a time base in half-minute graduations along its horizontal axis and pounds of milk along its vertical axis, is used to obtain relevant data from the milk-flow curves. By this means, values for (*a*) total yield of milk, (*b*) total milking time, (*c*) milking time to the start of the machine stripping, (*d*) yield before machine stripping, (*e*) duration of

machine stripping, (*f*) amount of machine strippings, (*g*) time before the first 0·2 lb milk was recorded, and (*h*) maximum milking rate in lb per min during any half-minute can be obtained directly. By the use of the data and other calculated information, the milking characteristics of individual experimental cows can be compared.

IV. DISCUSSION

The apparatus described is similar to that of Whittlestone (1953) in that increases in the weight of milk as milking proceeds are conveyed to a recording unit by electrical impulses. However, the details of the methods used in the two recorders are quite different. The apparatus as described here is simple to operate and robust. It has been designed as simply as possible so that it is easily portable and can be attached to any type of commercial milking plant. It is not completely automatic but requires an operator other than the milker to tend the recording device.

The inclusion of the special vacuum control valve permits the test unit to be used at a lower vacuum than that of the main plant, without the need for a special vacuum pump. Pulsation rate is also set in the test unit quite independently of conditions in the other units. Test cows can therefore be milked as desired without upsetting the normal milking procedure for the rest of the herd.

The design of the bucket and connections is such that emptying of milk into the main line is very rapid and easily controlled by the milker. Cleaning and sterilizing operations at the end of milking are also simple. On machines fitted with in-line cleaning, the bucket, teat-cups and lines can be joined to the main system and cleaned without dismantling.

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EFFECT OF VARIATION OF VACUUM LEVEL ON MILKING RATE OF AUSTRALIAN ILLAWARRA SHORTHORN COWS

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SUMMARY

Increasing the vacuum level from 10 in. to 16 in. increased the maximum milking rate and the overall milking rate. The increase in maximum rate was slightly greater for faster milking cows than for slower milkers.

Considerable variation in milking rates was found between cows. Faster milkers milked faster at 10 in. than did slower milkers at 16 in. Rates are compared with those reported by other workers for other breeds of cows.

Neither the amount of strippings nor stripping time appeared to be related directly to vacuum level.

The vacuum at the teat-cups approached the unit vacuum only towards the end of the milking period. The teat-cup vacuum during the period of fastest milking showed little difference with milking vacuum levels of 12, 14 and 16 in. for the fastest milking cows.

I. INTRODUCTION

In recent years considerable attention has been paid to the rate of milking of dairy cows, and several investigators in England, the United States and New Zealand have considered the effect of milking at different levels of vacuum. Smith and Petersen (1946) and Baxter, Clarke, Dodd, and Foot (1950) found that the rate of milking increased with increased vacuum. Gregoire, Mochrie, Elliot, and Spielman (1954) also reported that rates of flow appeared to be increased with an increase in vacuum level. Stewart and Schultz (1958) obtained similar results with randomly selected slow-milking cows. However, Whittlestone and Verrall (1947) working in New Zealand did not find any significant difference in the average milking rates of cows milked at 10, 14½ and 19 in. vacuum.

In order to obtain data on the milking rates of dairy cows under Queensland conditions, experiments were made using Australian Illawarra Shorthorn (A.I.S.) cows. These trials were conducted on the Atherton Tableland, at an altitude of 2,600 ft above sea level.

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II. EXPERIMENTAL PROCEDURE

(a) Cows Selected

The cows used in these trials were from a pure-bred A.I.S. commercial dairy herd. They were selected arbitrarily from those giving a fairly good yield of milk at the afternoon milking. The stage of lactation varied from $2\frac{1}{2}$ months to 6 months. On the first occasion recordings were obtained from 11 cows, and in the second series 12 cows were milked.

(b) Milking Methods

Milking was carried out using a "Ridd" milking machine fitted with "Alfa Laval" teat cups and pulsator. The "Swedish" synthetic inflations which were used were new at the beginning of the trials. This set of cups and inflations was used only on the occasions of test recordings. The pulsation rate was kept constant at 54 per minute, and at this rate the pulsator had a squeeze to release ratio of 30 : 70. This ratio was measured along the atmospheric pressure ordinate of the graph drawn by a "Ruakura" vacuum recorder. The air reserve of the 3-unit milking machine was checked, and it was maintained above the recommended level of 10–11 cu. ft. per min machine requirement (Phillips 1952).

A standard procedure was followed in preparing cows for milking. The udder was washed with warm water, then two squirts of foremilk were removed from each teat. The teat-cups were put on one minute after the start of washing.

(c) Recording

A record of the milking process was obtained using the apparatus described by Murray (1960). Milk entered the bucket through a milk-flow indicator. Machine stripping was commenced when the sight-glass was half-full, which indicated that the rate of milk flow had dropped to approximately 0·7 lb per min. The cups were removed when the operator considered that no milk remained in the udder or teat sinuses. All cows were hand-stripped to check on the efficiency of machine stripping.

Records of milking rates were obtained at the afternoon's milking on consecutive days at 16, 14, 12 and 10 in. vacuum. Before the test recordings and at the morning milkings, the cows were milked at 15 in. vacuum.

Table 1

RESULTS OF 23 RECORDINGS ON 13 COWS AT EACH OF FOUR LEVELS OF VACUUM

	Total Weight of Milk (lb)				Total Milking Time (min)				Percentage Strippings				Stripping Time (min)				Maximum Rate (lb per min)				Overall Rate (lb per min)			
Vacuum (in. Hg)	10	12	14	16	10	12	14	16	10	12	14	16	10	12	14	16	10	12	14	16	10	12	14	16
Cow—																								
1	13¾	16½	13¾	17	4·0	4·5	3·4	4·1	11·0	15·3	21·8	8·8	0·9	1·2	1·2	0·8	4·7	5·0	6·0	6·2	3·4	3·7	4·0	4·1
1	15¾	16¼	16	14	4·8	4·3	4·1	3·3	19·0	12·3	10·9	7·1	1·2	0·8	0·9	0·3	4·2	5·0	5·7	6·5	3·3	3·8	3·9	4·2
2	15	15½	16	16½	4·3	3·8	3·9	3·6	6·7	9·8	7·8	4·5	0·5	0·7	0·7	0·4	4·7	5·2	4·7	5·7	3·5	4·0	4·1	4·6
2	15¼	12½	12½	13	4·3	3·4	3·5	2·9	18·1	10·0	14·0	5·8	0·8	0·5	0·8	0·5	5·2	5·0	5·5	6·5	3·5	3·7	3·6	4·5
3	14	16½	14¾	18½	5·1	4·8	3·9	4·3	8·9	6·1	10·1	13·5	0·7	0·4	0·7	1·0	3·2	3·7	4·7	6·0	2·7	3·4	3·8	4·3
4	11	9½	12	11¼	3·8	2·8	3·1	2·7	9·1	2·5	2·1	4·4	0·3	0·1	0·3	0·2	3·0	4·2	5·0	5·2	2·9	3·4	3·9	4·2
5	15¼	15½	16⅜	15¼	5·4	4·7	4·1	3·9	13·1	8·1	1·6	1·6	1·0	0·7	0·3	0·2	3·5	4·5	5·2	5·5	2·8	3·3	4·1	3·9
5	14	15½	16½	15¼	5·3	5·0	4·4	3·5	12·5	6·5	3·1	1·6	0·7	0·3	0·3	0·2	3·0	3·7	4·2	5·5	2·6	3·1	3·8	4·3
6	15	17½	16⅜	17¼	4·9	5·0	4·0	3·9	11·7	8·6	10·4	7·2	0·6	0·6	0·6	0·6	4·5	4·2	5·0	5·0	3·1	3·5	4·2	4·4
6	16	17	16¼	13½	6·0	5·0	4·3	3·2	20·2	13·2	6·2	5·6	1·0	0·8	0·6	0·2	2·7	4·2	4·7	5·2	2·7	3·4	3·8	4·2
7	15½	16½	17	15	5·2	4·8	4·9	4·3	9·7	13·5	11·7	13·3	0·7	0·6	0·8	1·0	4·0	3·7	4·2	5·0	3·0	3·4	3·5	3·5
7	15¼	17	17½	16¼	5·6	5·4	5·6	4·4	21·3	17·6	12·9	15·4	1·0	0·9	1·2	0·8	3·2	3·7	4·2	5·2	2·7	3·1	3·1	3·7
8	12	12	12	14¾	5·1	4·2	4·2	4·3	10·4	14·5	18·8	13·5	0·5	0·7	1·0	0·9	2·7	3·2	3·7	5·0	2·4	2·9	2·9	3·4
8	11	14½	11½	15	5·2	5·4	4·0	4·8	27·3	13·8	8·8	11·7	1·2	0·8	0·7	1·0	2·5	3·2	3·7	4·5	2·1	2·7	2·9	3·1
9	13	11½	12½	13	5·4	4·3	3·9	4·2	21·2	15·3	20·0	15·4	1·0	0·6	0·9	0·9	2·7	3·0	4·0	4·5	2·4	2·7	3·2	3·1
9	14	13¾	13¼	13¼	5·2	4·1	4·2	3·2	10·7	9·1	15·1	11·3	0·7	0·4	0·9	0·7	3·5	4·0	4·5	5·7	2·7	3·4	3·2	4·1
10	12	12	12½	10½	4·8	3·9	3·8	2·8	4·2	4·2	10·3	4·8	0·2	0·4	0·8	0·3	3·0	3·7	4·0	5·0	2·5	3·1	3·2	3·8
11	9¾	12	12¼	13	4·5	5·1	4·5	4·5	20·5	10·4	16·3	9·6	0·8	0·4	0·6	0·7	2·5	2·5	3·2	3·5	2·2	2·4	2·7	2·9
11	10	12	15¼	11½	5·8	5·4	5·5	4·2	20·0	6·3	18·0	4·3	0·9	0·4	1·3	0·2	2·0	2·5	3·5	3·5	1·7	2·2	2·8	2·7
12	9¼	16	15	13¾	5·4	6·0	5·5	4·8	13·5	6·3	20·0	16·4	0·6	0·5	1·2	1·2	2·5	2·7	3·2	3·5	1·7	2·7	2·7	2·9
12	12¾	14½	15	12¾	7·0	5·8	5·8	4·3	17·6	15·4	10·0	3·9	1·1	1·0	0·9	0·4	2·0	3·0	3·0	3·7	1·8	2·5	2·6	3·0
13	11¼	14¼	15¾	12¾	6·2	6·3	6·0	4·3	13·3	19·3	11·1	9·8	0·8	1·1	0·7	0·6	2·2	2·5	3·2	3·5	1·8	2·3	2·6	3·0
13	14	14	13	14½	7·5	6·2	5·0	4·6	16·1	16·1	11·5	6·9	1·0	1·1	0·8	0·4	2·0	2·5	3·2	4·0	1·9	2·3	2·6	3·2
Average	13¼	14⅛	14⅛	14⅛	5·25	4·79	4·42	3·92	14·6	11·1	11·9	8·5	0·79	0·65	0·80	0·59	3·20	3·69	4·27	4·93	2·67	3·09	3·36	3·70

(d) Data Obtained

Visual inspection of the milk flow curves showed differences in milking rates between cows and between the different treatments. So that these differences could be evaluated the following data were obtained:

Total weight of milk.

Total milking time.

Maximum milking rate over any half-minute.

Overall milking rate obtained from total yield divided by total time.

Strippings expressed as a percentage of total yield.

During these trials records were also obtained of the vacuum at the teat-cups during the milking process and at the beginning of machine stripping.

III. RESULTS

The results for 23 recordings on 13 cows at each of the four levels of vacuum are shown in Table 1.

(a) Variation Between Cows

The figures obtained show that there was a wide variation between the milking rates of these cows under similar conditions. For example, the maximum milking rate at 16 in. varied from 3·5 to 6·5 lb per min, and at 10 in. from 2·0 to 5·2 lb per min.

The range of values for the overall rate showed similar variations, from 2·7 to 4·6 lb per min at 16 in., and from 1·7 to 3·5 lb per min at 10 in.

(b) Vacuum Level and Milking Rates

Decreasing the vacuum level from 16 in. to 10 in. caused a progressive decline in the maximum milking rate and the overall rate. The trends in milking rates for each individual cow were the same as for the averages of the 23 tests. The average results of these trends are shown graphically in Figure 1. It can be seen that the effect of vacuum level was slightly greater on maximum milking rate than on overall rate where machine stripping is included.

In Table 2, the average milking rates for 6 tests on faster milkers and 6 tests on slower milkers are shown for each vacuum level. The differences in milking rate between the faster and the slower milkers at any vacuum level were greater than the differences in milking rate at the 10 in. and 16 in. vacuum for each group. The faster milking cows milked more rapidly at 10 in. than the slower cows did at 16 in. The increase in maximum rate as the vacuum level increased was slightly greater for the faster than for the slower milking cows but the increase in overall rates was the same for both groups.

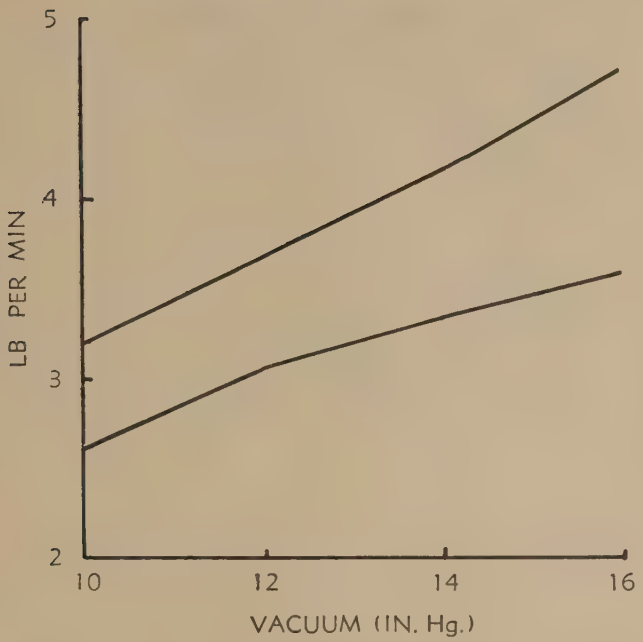

Fig. 1.—Average values for milking rates at four vacuum levels.

Table 2

AVERAGE MILKING RATES FOR 6 TESTS ON FAST MILKERS, AND 6 TESTS ON SLOW MILKERS AT FOUR VACUUM LEVELS

Vacuum Level (in. Hg)	Maximum Rate (lb/min)		Overall Rate (lb/min)	
	Fast Cows	Slow Cows	Fast Cows	Slow Cows
16 ..	6·0	3·6	4·3	3·0
14 ..	5·3	3·2	3·9	2·7
12 ..	4·7	2·6	3·7	2·4
10 ..	4·2	2·2	3·2	1·9

(c) Yield of Strippings and Stripping Time

The amount of strippings expressed as a percentage of the total yield is shown in Table 1. The average percentage was 14·6 at 10 in., 11·1 at 12 in., 11·9 at 14 in. and 8·5 at 16 in. vacuum. There was no indication in these results of any increase in the amount of strippings at the higher vacuum levels. The largest average amount of strippings was found at the 10 in. level.

There was little difference in the times for machine stripping at the different vacuum levels. The average stripping time was least at the 16 in. vacuum when the smallest amount of strippings was obtained.

(d) Vacuum at Teat Assembly

During the trials a vacuum gauge was attached to the milk claw rubber as close as possible to the teat-cup. Vacuum readings at this point were recorded at intervals throughout the milking and just before the beginning of machine stripping. There was regular oscillation of 1–2 in. in the reading on this gauge, caused by the pulsation in the teat-cups.

The readings obtained in trials with 11 cows milked at four different vacuum levels are set out in Table 3. There was a tendency for the teat-cup vacuum to be lower with a faster rate of milk flow. The vacuum readings taken at the time of maximum rate of milk flow were the lowest throughout the milking. As the end-point of machine milking was approached, and the rate of milk flow decreased, the teat-cup vacuum rose slightly until just before machine stripping, when it was 1–3 in. lower than the vacuum being applied to the unit.

IV. DISCUSSION

There were significant increases in the maximum milking rate with increasing vacuum, thus showing that the results obtained by Smith and Petersen (1946), Baxter *et al.* (1950), Gregoire *et al.* (1954) and Stewart and Schultz (1958) for various breeds applied also to A.I.S. cows in Queensland.

Stewart and Schultz reported that there was a greater increase in maximum rate between 10 in. and 12·5 in. than between 12·5 in. and 15 in. In contrast, the greatest increase occurred between 14 in. and 16 in. in this study.

Baxter *et al.* (1950) failed to obtain an increase in overall rate of flow as they increased the vacuum from 11 to 20 in., owing to the longer time necessary to remove the larger amounts of strippings at the higher vacuum levels. In these trials the overall rates increased with increasing vacuum and there was no indication of larger amounts of strippings at higher vacuum levels. A similar result was obtained by Stewart and Schultz (1958).

Several workers have reported wide variation in milking rates between cows when large numbers of animals of different breeds have been examined. Beck, Fryer, and Atkeson (1951) examined 102 cows of the Ayrshire, Guernsey, Holstein and Jersey breeds. At 15 in. vacuum, maximum milking rates varied from 3·4 to 12·8 lb per min. Stewart, Schultz, and Coker (1957), in an examination of 286 cows at 12·5 in., found an even greater range of values for maximum milking rate (1·3 to 14 lb per min), and Dodd (1953) quoted maximum rates varying from 1·00 to 10·40 lb per min. The variation between the small number of cows in the present trials was not as great as reported by the above workers. The actual milking rates tended to be lower than those quoted by the American workers but were comparable to the centre of the

Table 3

VACUUM READING AT TEAT-CUPS AT TIME OF FASTEST MILKING AND JUST BEFORE MACHINE STRIPPING

	Milking Vacuum (in. Hg)											
	16 in.			14 in.			12 in.			10 in.		
Cow	Max. Milking Rate (lb/min)	Teat-cup Vacuum at Time of Max. Rate	Teat-cup Vacuum at Stripping	Max. Milking Rate (lb/min)	Teat-cup Vacuum at Time of Max. Rate	Teat-cup Vacuum at Stripping	Max. Milking Rate (lb/min)	Teat-cup Vacuum at Time of Max. Rate	Teat-cup Vacuum at Stripping	Max. Milking Rate (lb/min)	Teat-cup Vacuum at Time of Max. Rate	Teat-cup Vacuum at Stripping
1	6·2	11	14	6·0	10	12	5·0	9	9	4·7	7	8
2	5·7	10	15	4·7	10	12	5·2	9	9	4·7	8	8·5
3	6·0	10	13	4·7	10·5	13	3·7	9	10	3·2	8	8·5
5	5·5	9	13	5·2	10·5	13	4·5	9	10	3·5	8·5	9
6	5·0	11	14	5·0	11	13	4·2	9	9	4·5	8·5	9
7	5·0	11	14	4·2	11	12	3·7	9	9	4·0	8·5	9
8	5·0	12	15	3·7	11	12	3·2	10	10	2·7	9	9
9	4·5	13	15	4·0	11	12	3·0	10	10	2·7	9	10
11	3·5	13	15	3·2	12	13	2·5	10	10	2·5	9	9
12	3·5	13	14	3·2	12	12	2·7	10	10	2·5	9	9
13	3·5	13	15	3·2	12	13	2·5	10	10	2·2	9	9

range reported by Dodd. The mean value for maximum rate in these trials was 4·93 lb per min, compared with a mean of 4·96 lb found by Dodd. Whittlestone and Verrall (1947) reported an average value for the overall milking rate of 2·64 lb per min at 15 in. vacuum. The comparable figure in the present study was 3·70 lb per min at 16 in., showing that this batch of cows milked faster than those tested by Whittlestone and Verrall.

Smith and Petersen (1946) and Baxter *et al.* (1950) found larger amounts of strippings at higher vacuum levels, and concluded that this was due to teat-cup crawl at the higher vacuum. There was no evidence of this effect in the present work at the vacuum levels used. Gregoire *et al.* (1954) suggested that 13 in. vacuum appeared to give more efficient milking, since the mean stripping time and the mean amount of strippings were lower than for 10 in. and 17 in. groups, and Stewart and Schultz (1958) found less strippings at 12·5 in. than at 15 in., although the stripping time remained the same. The least amount of strippings was actually found at 16 in. in these trials, suggesting that more efficient milking was obtained at this higher vacuum level.

Baxter *et al.* (1950) and Stewart and Schultz (1958) noted that the faster milking cows had a greater increase in maximum rate of flow as the vacuum increased than did the slower milking cows. Similar results were noted in the present work although the increases in the overall rate were about the same for both groups of cows.

Generally there was no difficulty in milking at 10 in. vacuum, although there was a tendency with some cows for the teat-cups to fall off.

Observations made on the level of negative pressure near the teat-cups showed that, during milking, this vacuum was considerably lower than the line vacuum, and that only when the rate of milk flow became very low did the vacuum level become nearly equal to that of the unit. This finding is in line with the effect noted by Petersen (1944) on vacuum in the teat. He stated that when milk flows freely into the teat there is no detectable vacuum in the teat sinus, but that when teat-cup crawl has closed the passage between udder and teat, the vacuum within the teat becomes identical with that in the milk-line. In the present work the vacuum at the teat-cups was lower during the period of maximum milking rate for the faster milkers than for the slower milkers. For the faster milking cows there was little difference in teat-cup vacuum when milking was carried out at 16, 14 and 12 in. vacuum. The possibility of greater udder injury at higher vacuum levels would therefore apply only if the teat-cups were left on the cow after milk-flow ceases.

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CHEMICAL CONTROL OF NEMATODES IN SOUTH QUEENSLAND PINEAPPLE FIELDS

By R. C. COLBRAN, M.Agr.Sc.*

SUMMARY

The nematode complex associated with the Smooth Cayenne variety of pineapple in Queensland includes the root-knot nematode Meloidogyne javanica **(Treub), the root-lesion nematode** Pratylenchus brachyurus **(Godfrey), the spiral nematode** Helicotylenchus nannus **Steiner and a ring nematode,** Criconemoides ornatum **Raski.**

In field trials on replant land in South Queensland, soil fumigation with DD, EDB and "Nemagon" prior to planting or shortly afterwards reduced the nematode populations and increased the size of the fruit. When fumigants were injected around 7-month-old plants heavily infested with Meloidogyne javanica **and** Pratylenchus brachyurus **there was a marked response to "Nemagon" (a yield increase of 9-18 per cent.), but not to EDB and "Vapam."**

I. INTRODUCTION

A problem associated with the culture of the pineapple (*Ananas comosus* L.) is that of declining yields and fewer ratoons on replant land. High populations of ectoparasitic and endoparasitic nematodes are a feature of many replant areas.

Godfrey (1929) described the root-lesion nematode *Tylenchus brachyurus* and demonstrated that it was a factor contributing to root failure in pineapples in Hawaii. The effect of root-knot nematodes was studied by Godfrey and Oliveira (1932) and Godfrey and Hagan (1937). Johnson and Godfrey (1932) showed that the use of chloropicrin prior to replanting controlled the root-knot nematode *Heterodera marioni* (Cornu) and resulted in increased pineapple yields. In 1945, Carter reported on the value of DD and this material is now widely used in Hawaii.

In Puerto Rico, Alvarez-García and López-Matos (1954) reported increased yields of the Red Spanish variety of pineapples on replant ground following preplant treatment with DD, EDB and methyl bromide.

Three field trials reported in this paper were designed to compare DD, EDB and "Nemagon" as preplant treatments; the fourth to determine whether the yield of an established planting heavily infested with a nematode complex could be increased by treatment with either EDB, "Nemagon" or "Vapam".

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II. SPECIES INVOLVED

During 1959-60 a nematode survey was carried out to determine the distribution of the probable pest species in South Queensland plantations. In the 50 plantings sampled the only species present in sufficient numbers to affect seriously the growth of the plants were the root-knot nematode *Meloidogyne javanica* (Treub), the root-lesion nematode *Pratylenchus brachyurus* (Godfrey), the spiral nematode *Helicotylenchus nannus* Steiner and a ring nematode, *Criconemoides ornatum* Raski.

Meloidogyne javanica is widely distributed, occurring in more than 90 per cent. of the plantings sampled, and must be regarded as the most important of these species.

Pratylenchus brachyurus was found in 30 per cent. of the plantings. Some areas of unsatisfactory growth were associated with high populations of this pest.

Helicotylenchus nannus was found in every pineapple plantation sampled, and in most instances was the common nematode in the complex, up to 5000 per 400 ml being extracted from soil samples. Frequently large numbers of this ectoparasite were found feeding on pineapple roots. *Criconemoides ornatum* was abundant in two plantings at Beerwah. The pathogenicities of *Helicotylenchus nannus* and *Criconemoides ornatum* have not been established.

In addition to these four species the following were found in association with pineapple roots:—*Hemicycliophora truncata* Colbran, *Psilenchus tumidus* Colbran, *P. magnidens* Thorne, *Pseudhalenchus minutus* Tarjan, *Ditylenchus myceliophagus* J. Goodey, *Aphelenchus avenae* Bastian, *Aphelenchoides saprophilus* Franklin, *Pratylenchus zeae* Graham and *Trichodorus minor* Colbran.

The reniform nematode *Rotylenchulus reniformis* Linford and Oliveira occurs as a parasite of tomatoes and papaws in the Rockhampton area but has not been found in pineapple fields. There is no record of the pin nematode *Paratylenchus minutus* Linford, Oliveira and Ishii from Queensland.

III. MATERIAL AND METHODS

(a) General

The nematocides used were:—

DD.—A mixture of 1,3 dichloropropene and 1,2 dichloropropane containing 50-59 per cent. 1,3 dichloropropene and 55-60 per cent. weight of total chlorine. Sp.gr. 1·2.

"Nemagon."—A compound containing 97 per cent. by weight of 1,2 dibromo-3-chloro-propane. Sp.gr. 2·08. Impurities are mainly related hydrocarbons; inert compounds not exceeding 1 per cent. by weight.

EDB.—Ethylene dibromide in power kerosene. (EDB (sp.gr. $\frac{25}{25}$ 2·17) content 12·5 per cent.v/v).

"Vapam."—A solution containing 5 lb sodium N-methyl dithiocarbamate per gal.

Pineapples were grown on the double-row system with 6 ft between bed centres, 20-24 in. between rows in each bed and 9-12 in. between plants in the row. Each trial plot consisted of one double row.

Fumigants were applied either by hand injector in four rows per bed, each row 6 in. from a plant row, and injections 1 ft apart in the row; or by a Bowen Auchincruive gravity injector in three rows, one down the middle of the bed fed by two tubes and two each 6-9 in. outside the plant rows fed by single tubes. The machine injector was used after planting and it was not practicable to use two tines between the rows in the bed.

Soil samples to a depth of 9 in. between the plants in the row were taken with a small auger. Each plot sample consisted of 10 sub-samples. Nematodes were extracted by the Seinhorst ehrlenmeyer method (Seinhorst 1956). As "Nemagon" kills nematodes at a slower rate than DD or EDB, soil samples were not taken until 6-9 months after treatment.

(b) Trial 1, Beerwah

The trial site had been planted with tops in December 1955. By July 1956 the plants were of poor colour and vigour. A root examination showed that the majority of plants were heavily infested with *Meloidogyne javanica,* typical plants having an abundance of short extension roots with terminal galls. This trial was designed to determine whether plants in this condition would respond to EDB, "Nemagon" or "Vapam". These chemicals were applied at a depth of 6 in. by means of a hand injector. Three injection patterns were used:—

(*a*) *Between the plants.*—One injection midway between the plants in each row.

(*b*) *At the plant base.*—One injection as close to the stem as possible without mechanically injuring the plant.

(*c*) *Three-row.*—The fumigant applied in three rows along each bed with injections in each row 12 in. apart; one row down the middle of the bed; the others each 6-9 in. from the row on the outer side. Injections were opposite the middle of the interplant space in the adjacent row.

The layout was a 5 x 4 rectangular lattice with 4 replications of 20 treatments including 5 control plots. Each plot contained 45 datum plants. Treatments were applied on July 11, 1956. Growth ratings were made on November 29, 1957. The ratings used, 1-5, correspond to an increase in vigour and desirable colouration. Root samples for nematode counts were taken on the same date. The nematodes were extracted by macerating the roots in a blender and separated from the plant material by flotation and the use of the Baermann funnel technique. Harvesting of the plant crop extended from February 6, 1958, to April 8, 1958, and of the first ratoon from January 28, 1959, to March 31, 1959.

(c) Trial 2, Beerwah

The layout was a split-plot design with 5 replications. The two whole-plot treatments corresponded to time of fumigation, namely (A) hand injector on September 11, 1957, and (B) gravity injector on October 1, 1957. The four sub-plot treatments were concerned with fumigants, and each sub-plot contained 140 datum plants. The trial was planted on September 18, 1957.

Harvesting of the summer section of the plant crop extended from January 28, 1959, to April 29, 1959, and of the winter section from May 20, 1959, to October 21, 1959.

Soil samples were taken on June 30, 1958. Excess slips and suckers were removed and weighed on December 9, 1959.

(d) Trial 3, Woombye

This trial was established on replant land at Woombye, and was based on a 4 x 6 randomized block layout. Each plot was two chains in length. The fumigants were applied by hand injector on November 21, 1957. Tops were planted two days later. Soil samples were taken for nematode counts on July 29, 1958, and leaf measurements on August 14, 1959. Harvesting of the winter section of the plant crop extended from August 19, 1959, to December 2, 1959, and of the summer section from December 9, 1959, to March 16, 1960.

(e) Trial 4, Kandanga

A 4 x 6 randomized block layout, with plot length of 122 ft, was used. Suckers were planted on October 28, 1957, and the fumigants were applied by gravity injector on November 6, 1957. Soil samples were taken on August 12, 1958. The harvesting of the plant crop extended from February 23, 1959, to November 11, 1959.

IV. RESULTS

(a) Trial 1

Results (Tables 1 and 2) show that the injection of "Nemagon" at rates of 0·50 ml and 0·75 ml per hole resulted in improved growth and mean fruit weight, irrespective of the injection pattern. The increase in mean fruit weight in the plant crop ranged from 9 to 18 per cent. "Nemagon" at 0·50 ml per hole (3-row) and 0·75 ml (between plants, plant base) also increased mean fruit weight in the first ratoon crop. The use of EDB and "Vapam" did not improve the plants.

Counts of nematodes from root samples four months after fumigation with "Nemagon" showed a marked reduction in infestation of root-lesion nematodes. The method used proved unsuitable for determining severity of root-knot nematode infestation.

Table 1

TRIAL 1: EFFECT OF FUMIGATION AROUND 7–MONTH–OLD PINEAPPLE PLANTS ON MEAN FRUIT WEIGHT

Fumigant	Injection		Mean Fruit Weight for Plant Crop	Mean Fruit Weight for First Ratoon Crop
	Rate (ml)	Placement	(oz)	(oz)
EDB	2	Between plants	43·7	41·8
EDB	2	Plant base	47·0	40·5
EDB	2	3-row	46·7	44·5
" Nemagon " ..	0·25	Between plants	48·6	42·2
" Nemagon " ..	0·25	Plant base	47·7	42·2
" Nemagon " ..	0·25	3-row	50·1	42·2
" Nemagon " ..	0·50	Between plants	52·2	46·5
" Nemagon " ..	0·50	Plant base	54·1	45·0
" Nemagon " ..	0·50	3-row	54·1	49·5
" Nemagon " ..	0·75	Between plants	54·1	50·0
" Nemagon " ..	0·75	Plant base	54·1	48·8
" Nemagon " ..	0·75	3-row	56·5	47·5
" Vapam " ..	1·5	Between plants	47·8	44·5
" Vapam " ..	2·2	Between plants	45·6	43·2
" Vapam " ..	3·0	Between plants	50·1	45·2
Control	..	..	48·0	43·7
Necessary differences for significance 5%			2·6	4·9
Necessary differences for significance 1%			3·4	6·6

Table 2

TRIAL 1: EFFECTS OF FUMIGATION AROUND 7-MONTH-OLD PINEAPPLE PLANTS ON GROWTH AND NEMATODE POPULATION

Fumigant	Injection		Growth Rating		Root-lesion Nematodes (1 oz roots)	
	Rate (ml)	Placement	$\sqrt{x+\frac{1}{2}}$	Equiv. Rating	log (1 + x)	Equiv. Rating
EDB	2	Between plants	1·56	1·9	2·76	567·9
EDB	2	Plant base	1·71	2·4	2·01	101·3
EDB	2	3-row	1·80	2·7	1·16	13·6
" Nemagon " ..	0·25	Between plants	1·86	3·0	1·98	95·6
" Nemagon " ..	0·25	Plant base	1·87	3·0	0·90	6·9
" Nemagon " ..	0·25	3-row	2·05	3·7	1·05	10·2
" Nemagon " ..	0·50	Between plants	2·12	4·0	0·00	0
" Nemagon " ..	0·50	Plant base	2·24	4·5	0·00	0
" Nemagon " ..	0·50	3-row	2·29	4·8	0·00	0
" Nemagon " ..	0·75	Between plants	2·23	4·5	0·94	7·7
" Nemagon " ..	0·75	Plant base	2·24	4·5	0·00	0
" Nemagon " ..	0·75	3-row	2·35	5·0	0·00	0
" Vapam " ..	1·5	Between plants	2·06	3·7	2·24	174·8
" Vapam " ..	2·2	Between plants	1·92	3·2	2·00	100·2
" Vapam " ..	3·0	Between plants	1·83	2·9	2·03	106·2
Control	..	..	1·82	2·8	2·12	131·4
Necessary differences for significance	5%		·27	..	1·50	..
	1%		·36	..	2·04	..

(b) Trial 2

Soil treatment with DD, EDB and "Nemagon" reduced the soil population of root-knot nematode larvae and spiral nematodes and increased the mean fruit weight for both the summer and winter sections of the plant crop (Tables 3 and 4). The increase ranged from 16 to 27 per cent. A greater weight of slips and suckers was stripped from plants in the fumigated plots than in the untreated plots, indicating that the benefits of fumigation would be carried over into the first ratoon crop. The plants in plots treated with "Nemagon" and EDB were superior at this stage to those in the DD-treated plots.

As differences in mean fruit weight due to time of fumigation were not significant, separate means are not included in Tables 3 and 4.

Table 3

TRIAL 2: EFFECTS OF FUMIGATION ON MEAN FRUIT WEIGHT AND WEIGHT OF SURPLUS SLIPS AND SUCKERS

Treatment	Mean Fruit Weight (oz)		Slips and Suckers (lb)
	Summer	Winter	
EDB 16·6 gal/ac	68·9	77·9	406·0
DD 16·6 gal/ac	64·6	78·9	315·5
" Nemagon " 4 gal/ac	65·7	78·5	417·1
Control	54·1	67·2	261·8
Necessary differences for significance 5%	1·7	5·3	66·3
Necessary differences for significance 1%	2·2	7·1	90·9

Table 4

TRIAL 2: EFFECT OF FUMIGATION ON NEMATODE POPULATIONS

Treatment	Root-knot Nematode Larvae (½ lb soil)		Spiral Nematodes (½ lb soil)	
	$\sqrt{x + \frac{1}{2}}$	Equiv. No.	$\sqrt{x + \frac{1}{2}}$	Equiv. No.
EDB 16·6 gal/ac	6·03	36	7·80	60
DD 16·6 gal/ac	7·23	52	9·25	85
" Nemagon " 4 gal/ac	4·41	19	7·33	53
Control	9·31	86	14·58	212
Necessary differences for significance 5%	3·49	..	5·30	..
Necessary differences for significance 1%	4·73	..	7·18	..

(c) Trial 3

Treatment with EDB, DD and "Nemagon" reduced the soil population of root-knot nematode larvae and spiral nematodes, and increased the size of the plants and the mean fruit weight by 5-19 per cent. (Tables 5 and 6.)

Table 5

TRIAL 3: EFFECT OF SOIL FUMIGATION ON MEAN FRUIT WEIGHT

Treatment	Mean Fruit Weight (oz)	
	Winter Plant Crop	Summer Plant Crop
EDB 16·6 gal/ac	81·0	54·9
DD 16·6 gal/ac	78·3	52·0
" Nemagon " 5 gal/ac	82·1	55·9
Control	74·6	47·0
Necessary differences for significance 5%	4·5	3·4
Necessary differences for significance 1%	6·2	4·7

Table 6

TRIAL 3: EFFECTS OF SOIL FUMIGATION ON NEMATODE POPULATIONS AND LEAF LENGTH

Treatment	Root-knot Nematode Larvae (½ lb soil)		Spiral Nematodes (½ lb soil)		Mean Length of Longest Leaf (cm)
	$\sqrt{x}$	Equiv. No.	$\sqrt{x}$	Equiv. No.	
EDB 16·6 gal/ac ..	10·9	118	5·5	30	90·5
DD 16·6 gal/ac ..	12·7	162	16·7	279	89·0
" Nemagon " 5 gal/ac	7·7	59	5·2	27	91·8
Control	16·2	262	22·0	483	81·5
Necessary differences for significance 5%	4·7	..	8·2	..	3·8
Necessary differences for significance 1%	6·6	..	11·4	..	5·2

(d) Trial 4

Results (Table 7) indicate a lack of response to fumigation. This failure was due probably to the dry condition of the soil when the treatments were applied and incomplete filling of the furrows behind the tines delivering the fumigants.

Table 7

TRIAL 4: EFFECTS OF SOIL FUMIGATION ON NEMATODE POPULATIONS AND MEAN FRUIT WEIGHT

Treatment	Root-knot Nematode Larvae (½ lb soil)	Spiral Nematodes (½ lb soil)	Mean Fruit Weight (oz)
EDB 16·6 gal/ac	453	46	62·9
DD 16·6 gal/ac	310	98	61·7
" Nemagon " 5 gal/ac	617	190	59·5
Control	480	214	59·0

V. CONCLUSION

Results of the survey and these trials are the basis of recommendations for the commercial control of nematodes in South Queensland pineapple fields (see Colbran 1960).

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STUDIES OF PLANT AND SOIL NEMATODES

3. *BELONOLAIMUS HASTULATUS, PSILENCHUS TUMIDUS* AND *HEMICYCLIOPHORA LABIATA*, THREE NEW SPECIES FROM QUEENSLAND

By R. C. COLBRAN, M.Agr.Sc.*

SUMMARY

Three new species, Belonolaimus hastulatus, Psilenchus tumidus **and** Hemicycliophora labiata, **are described.** B. hastulatus **is distinguished by a short stylet and four sublateral incisures in each lateral field and** Psilenchus tumidus **by a single ovary and swollen tail tip.** Hemicycliophora labiata **resembles** H. typica **de Man,** H. similis **Thorne and** H. gracilis **Thorne but differs in having a single continuous lateral incisure and protuberant anterior vulval lip.**

Belonolaimus hastulatus n.sp.

(Figure 1)

Females.—L = 920–1110 μ; a = 39–59; b = 11·0–13·1; c = 23–29; V = 52–58; stylet = 30–33 μ.

Holotype.—L = 1055 μ; a = 39·0; b = 12·3; c = 28·6; V = 52·6; stylet = 31 μ.

Males.—L = 890–1000 μ; a = 40–62; b = 11·0–12·6; c = 18–26; stylet = 29–31 μ; spicules = 22–25 μ; gubernaculum = 11–12μ.

Allotype.—L = 944 μ; a = 40·9; b = 11·0; c = 19·8; stylet = 31 μ; spicules = 24·5 μ; gubernaculum = 11·6 μ.

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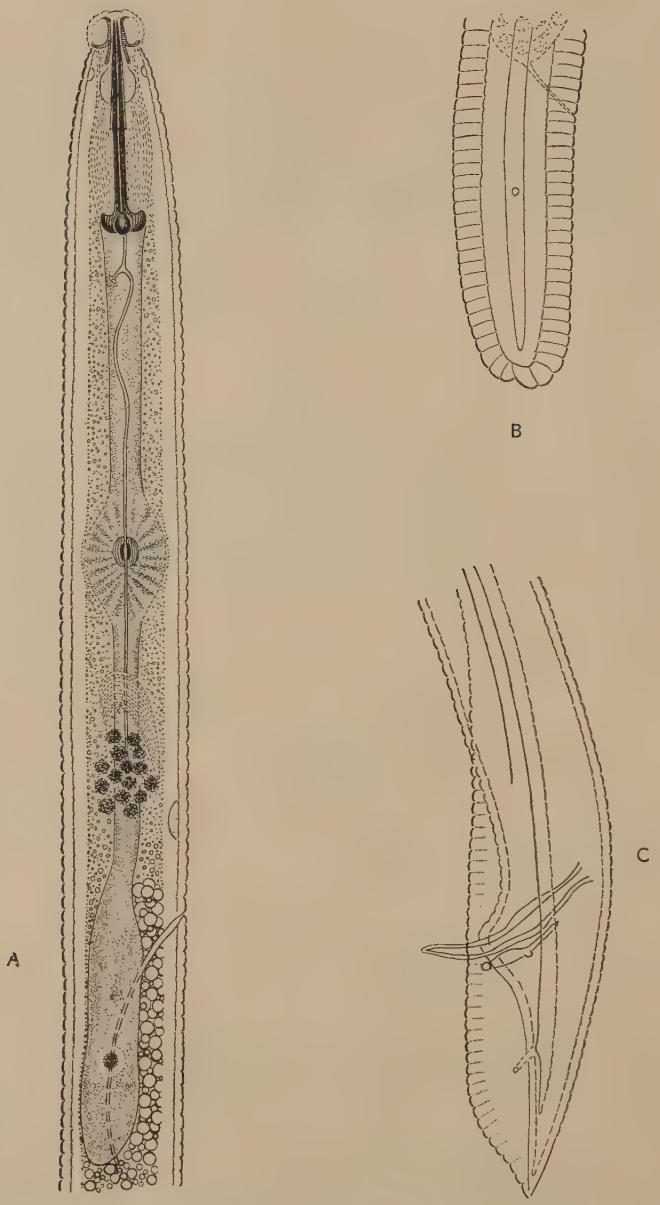

Fig. 1—*Belonolaimus hastulatus* n.sp. A. Oesophageal region (× 1000). B. Female tail (× 1000). C. Male tail (× 1000).

Body cylindrical, assuming an arcuate position when relaxed. Lip region globular, set off by a constriction and marked by 6 or 7 transverse striae. Cuticle with coarse striations 2·0–2·3 μ apart in the middle of the body. Lateral fields marked by four sublateral incisures over the greater part of their length. Outer incisures crenate. Two incisures from the metacorpus to the middle of the stylet. Stylet 31 μ long with well developed basal knobs. Knobbed base of the stylet 5 μ in width. Anterior face of knobs concave. Prorhabdion a little longer than half the length of the stylet. Dorsal gland orifice 5μ behind base of stylet. Vestibule extension well developed. Metacorpus with sclerotized valve 4 μ long. Oesophageal glands in a long lobe overlapping intestine. Excretory pore opposite anterior end of lobe. Hemizonid conspicuous, 5 or 6 annules anterior to excretory pore. Phasmids distinct, in anterior half of tail. Vulva equatorial: vagina extending half way across body. Ovaries paired, opposed, outstretched. Oocytes in a single row except for a short area near the cap cell. Tail cylindrical, 2·1 anal body diameters in length. Terminus hemispherical. Cuticular striations continuous around the terminus, coarser than in other parts of the body giving the tip an indented appearance.

Male similar in general appearance to female. Phasmids opening on to caudal alae which envelop tail tip. Edge of caudal alae crenate. Spicules large, arcuate and heavily sclerotized. Gubernaculum thickened in distal half, extrusible and cephalated.

Types.—Holotype (female) and allotype (male) Slide Reg. No. G 2446 in the Queensland Museum; labelled paratypes in the Queensland Department of Agriculture and Stock Nematology Collection.

Occurrence.—Belonolaimus hastulatus was collected in May 1959 from soil around the roots of a Late Valencia orange on sweet orange rootstock at Mundubbera, Queensland.

Diagnosis.—Belonolaimus hastulatus is distinguished by the presence of four sublateral incisures on each side of the body and the short stylet.

Psilenchus tumidus n.sp.

(Figure 2)

Fig. 2.—*Psilenchus tumidus* n.sp. A. Oesophageal region (× 1000). B. Female post-vulval region (× 1000). C. Male anal region (× 1000).

Females.—L = 555-639 μ; a = 28–34; b = 5·5–6·6; c = 5·8–8·0; V = 66–73; stylet 11–13 μ.

Holotype.—L = 569 μ; a = 29·3; b = 6·4; c = 6·7; V = 70.

Males.—L = 520–598 μ; a = 31–34; b = 5·6–6·3; c = 6·3–7·8; stylet = 11–13 μ; spicules = 18–20 μ; gubernaculum = 5·6 μ.

Allotype.—L = 528 μ; a = 31·1; b = 5·6; c = 7·4; stylet = 11·0 μ.

Body practically straight when relaxed. Cuticle with fine transverse striae 1·0–1·5 μ apart. Lateral field about 5 μ wide in middle of body, consisting of 4 incisures, the outer pair crenate. Incisures extend to middle of tail. Excretory pore opposite terminal oesophageal bulb. Deirids at latitude of excretory pore. Hemizonid immediately anterior to excretory pore, two body annules long. Amphid apertures slit-like, about half as wide as head, located towards base of lateral lips. Head slightly set off, without transverse striae. Stylet slender, 12·2 μ long with knobbed base 1·6 μ wide. Dorsal oesophageal gland opening into lumen of oesophagus at base of stylet. Median bulb of oesophagus ovate, terminal bulb elongate. Distance from anterior end to valve of median bulb less than half distance from anterior end to oesophago-intestinal valve. Vulva a transverse slit 11 μ wide. Ovary single, prodelphic, outstretched. Oocytes in single row. Oviduct cellular with a narrow lumen. Spermatheca present. Post-vulval uterine sac about two-thirds as long as width of body at vulva.

Male similar to female. Bursa adanal, extending a little further posterior to anus than anterior to it. Spicules curved, 19 μ long. Gubernaculum narrow, 5 μ long, slightly arcuate.

Types.—Holotype (female) and allotype (male) Slide Reg. No. G 2447 in the Queensland Museum; labelled paratypes in the Queensland Department of Agriculture and Stock Nematology Collection.

Occurrence.—*Psilenchus tumidus* was collected in December 1959 in a field of volunteer weeds, predominately *Digitaria adscendens* (H.B.K.) Henrard, at Glasshouse Mountains, Queensland.

Diagnosis.—*Psilenchus tumidus* is distinguished by the presence of one ovary, a slender, knobbed stylet and a clavate tail.

Hemicycliophora labiata n.sp.

(Figure 3)

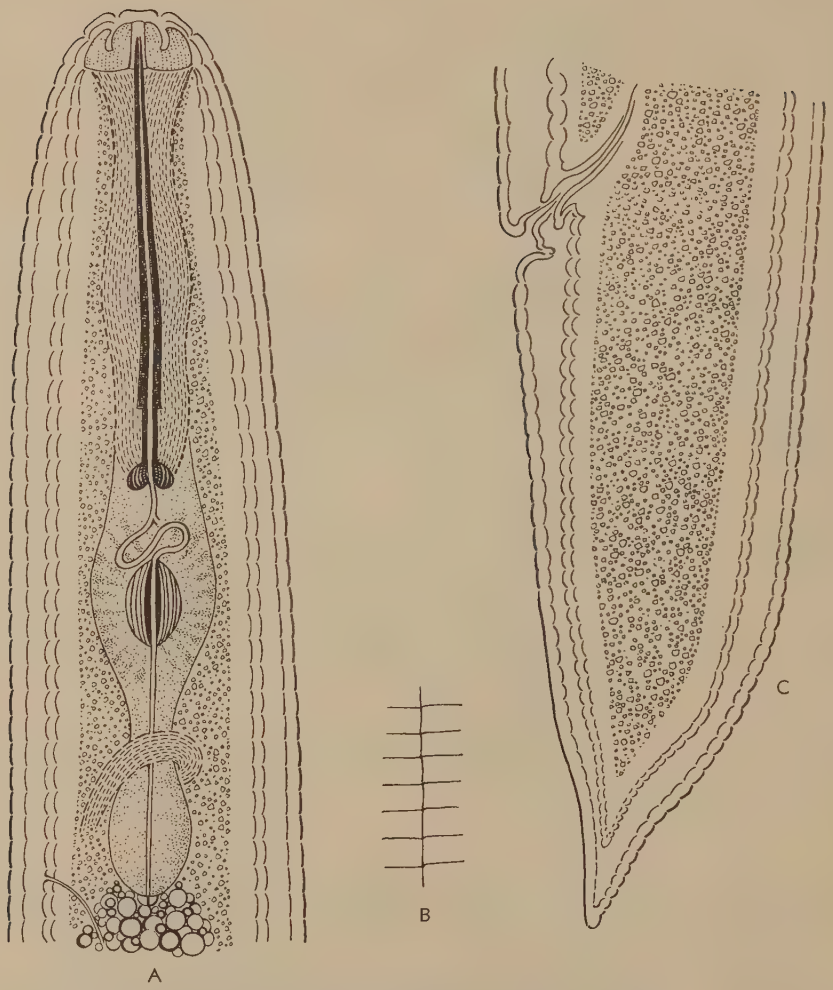

Fig. 3.—*Hemicycliophora labiata* n.sp. A Oesophageal region (× 1000). B. Lateral field (× 1000). C. Female post-vulval region (× 1000).

Females.—L = 700–860 μ; a = 19–24; b = 5·2–6·1; V = 81–86; stylet = 66–75 μ.

Holotype.—L = 701 μ; a = 21·2; b = 5·2; V = 82.

Body straight when relaxed. Outer adult cuticle with flattened annules approximately 4·4 μ wide in middle of body and separated from inner cuticle except at vulva and head. Annules on inner cuticle rounded, much wider and better defined in middle of body than on tail. Number of annules approximately 200. Lateral fields on outer cuticle each consisting of a single continuous incisure. Head rounded in front, not set off, with two annules, more clearly defined on outer cuticle. Labial cap present. Six well-defined lips, 2 lateral, 2 sub-dorsal, 2 sub-ventral. Stylet 68 μ long, dorsally arcuate, extending through 16 body anules. Prorhabdion 54 μ long. Knobs rounded, projecting posteriorly. Dorsal oesophageal gland orifice situated near base of stylet. Oesophagus typical of genus. Excretory pore near level of oesophago-intestinal valve. Nerve ring crossing anterior part of terminal bulb. Vulva with protuberant anterior and posterior lips. Ovary prodelphic, outstretched. Body constricted immediately posterior to vulva. Post-vulval uterine sac absent. Anus obscure. Tail convex-conoid with a sub-acute terminus.

Types.—Holotype Slide Reg. No. G 2448 in the Queensland Museum; labelled paratypes in the Queensland Department of Agriculture and Stock Nematology Collection.

Occurrence.—Hemicycliophora labiata is described from specimens collected in October 1959 around the roots of *Entolasia stricta* (R.Br.) Hughes in a wallum soil, Portion 377, Parish of Oxley, Brisbane. The species occurs also at Mulambin Beach, Central Queensland.

Diagnosis.—H.labiata is closely related to *H.typica* de Man, *H.similis* Thorne and *H.gracilis* Thorne. It can be distinguished from these species by the presence of a single continuous lateral incisure on each side of the body and the protuberant anterior lip of the vulva.

Acknowledgement

Mr. W. W. Manley, Departmental Illustrator, assisted in the preparation of the drawings.

(Received for publication January 4, 1960)

STUDIES OF THE COCCOIDEA. 11. NEW GENERA AND SPECIES OF MONOPHLEBIDAE

By A. R. BRIMBLECOMBE, M.Sc., Ph.D.*

SUMMARY

New genera of insects from Queensland described in the family Monophlebidae† are Araucaricoccus **and** Conifericoccus. **New species described in these genera are** A. queenslandicus, C. agathidis, C. invaginatus **and** C. notabilis. C. agathidis **is recorded from southern kauri pine** (Agathis robusta), **the others from hoop pine** (Araucaria cunninghamii).

ARAUCARICOCCUS new genus

Generic type.—*Araucaricoccus queenslandicus* new species.

Characters.—Adult female large and membranous. Antennae long, 9-segmented, anterior segments irregularly striated. Mouthparts atrophied. Thoracic spiracles plate-like, atrium shallow; abdominal spiracles in seven pairs. Legs well developed, similar, tarsus one-segmented, claw small. Anterior region of abdomen constricted, abdomen becoming invaginated during oviposition. Body dorsally and ventrally with numerous multiocular disk pores and rim ducts. Anal opening atrophied.

Notes.—This genus appears to be related to *Matsucoccus,* but differs markedly in size, in having one-segmented tarsi, in the absence of cicatrices and by inhabiting a large induced gall.

Araucaricoccus queenslandicus new species

(Figure 1)

Locality and host.—Queensland; Yarraman, on *Araucaria cunninghamii* D.Don, Sept. 1936.

Habit.—Occurring on plantation trees adjacent to standing rain-forest containing the host species. Insects sparse on small branches and twigs.

Recognition characters.—Adult female large, membranous, elongate-oval with a constriction about the anterior abdominal region, length of slide specimens up to 22·0 mm, width to 9·0 mm. Antennae well developed, 9-segmented, slightly shorter than combined length of tibia and tarsus, extended length 4·0 mm; segment 1 widest, quadrate, margins anteriorly convergent; 2 shortest; 4 to 6 subequal in length and in width; 7 to 9 progressively longer and narrower; 3 to 8 with margins anteriorly divergent; 9 oval; 3 with light dorsal thickening

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†Based on the group name "Monophlebites" of Signoret, V.: 1875: Ann. Soc. Ent. France (5) 5, p. 350.

Fig. 1.—*Araucaricoccus queenslandicus.* A, outline of body (× 7·5). B, antenna (× 25). C, multilocular disk pore (× 1055).

progressively more encircling on anterior segments, completely encircling segments 7, 8 and 9; surface of anterior segments irregularly striated; setae fine and short, in an apical ring on segments 3 to 8, scattered on 9, apparently absent on 1 and 2; scattered sensory spots on 9. Eye spots small dome-shaped structures latero-posteriorly to antennal bases. Mouthparts atrophied. Thoracic spiracles plate-like, atrium larger, shallow, without pores. Abdominal spiracles in seven pairs, present on anterior segments. Legs well developed, of similar shape and size. Coxa large and broad with some minute setae. Trochanter small with a transverse row of minute setae. Femur sub-cylindrical, sclerotized dorsally. Tibia sub-cylindrical, longer than femur, slightly sclerotized dorsally, distally inwardly curved, setae minute and scattered. Tarsus one-segmented, slender, widest medianly, inwardly curved distally, slightly longer than half the length of the tibia, with four terminal setae; claw small, with two digitules. Abdomen constricted about anterior segments. Anal opening atrophied. Simple small rim-ducts numerous on dorsal surface, scattered on ventral surface. Multilocular disk pores on dorsal surface more numerous on ventral surface, innumerably crowded on abdominal segments beyond the third, absent on apex. Body generally with a fine areolation.

Notes.—The tibiae may be appreciably curved distally. The tarsi, in addition to the normal distal curving, may at about one-third of their length be further curved to almost 90 degrees. In some specimens the number of pores on the dorsal and ventral surfaces may be subequal and similarly with the rim ducts. Some disk pores have the appearance of small cicatrices.

This insect forms comparatively large fleshy galls on young branches and twigs of the host. From the heavily sclerotized pyriform second stage within the gall the flaccid adult emerges backwards through a small circular opening on the posterior apex from which a neat dome-shaped cap has been forced away. The soft body makes the insect slow and awkward, and movement from the site of emergence is not great. During oviposition the abdomen is invaginated from the posterior end and the whole derm becomes hard and brittle. Males are not known.

Type Reg. No. T 5812 and paratypes T 5813 to T 5815 in the Queensland Museum.

CONIFERICOCCUS new genus

Generic type.—Conifericoccus invaginatus new species.

Characters.—Adult female membranous. Antennae and legs well developed. Antennae 9-segmented. Femur and tibia subequal in length. Body with dorsal and ventral segmental bands of large multilocular disk pores, cicatrices absent.

Notes.—The multilocular disk pores have a small simple open centre which sometimes may be eccentrically placed. In some instances the centres are not distinct and the pores may appear like a sieve. Cicatrices are absent although the multilocular interior of the pores on the posterior abdominal segments may be indistinct, thus giving the pores the appearance of small cicatrices.

The genus closely resembles *Matsucoccus,* which is confined to the northern hemisphere on species of *Pinus* as hosts, but differs in that cicatrices are absent, there are no pores within the atrium of the thoracic spiracles and the multilocular disk pores do not have a bilocular centre.

Conifericoccus invaginatus new species

(Figure 2)

Locality and host.—Queensland; Imbil, on *Araucaria cunninghamii* D. Don, Oct. 1936.

Habit.—Occurring on plantation trees in rain-forest areas with adjacent standing rain-forest containing the host species. Insects sparse to numerous under loose bark, in bark crevices and lenticels on trunks and branches. Adults may be accompanied by a slight amount of fine mealy material.

Recognition characters.—Adult female membranous, elongate-oval, slightly constricted about the anterior abdominal segments, length of slide specimens 2·25 to 3·0 mm, width 1·0 to 1·25 mm. Antennae terminal, long, 9-segmented; segment 9 longest, narrowest, oval, almost twice as long as 8, with many setae; 2 to 8 subequal in length, progressively slightly narrower, sometimes slightly sclerotized, margins anteriorly divergent, each with an anterior ring of setae; basal segment longer, always membranous, one-and-a-half times wider than segment 2; segment 9 with irregular transverse striations progressively less noticeable on segments 8, 7 and 6. Mouthparts atrophied, position indicated merely by a faint short longitudinal fold. Legs well developed, shorter than the antennae; coxa broad; trochanter small; femur and tibia subequal in length; femur broad, distally grooved on the inner side to receive the basal portion of the tibia, with a few scattered setae; tibia subcylindrical, less than half the width of the femur, with scattered setae but a definite longitudinal row on the inner distal margin, longer and spaced closer on the distal end of the tibia; tarsus two-segmented, half as long as the tibia, first segment short, second segment with a few setae in a line on the inner edge; claw stout, shorter than the first tarsal segment, with two digitules. Thoracic spiracles small, with an associated sclerotized rod; abdominal spiracles small, in seven pairs. Anterior body ventrally with a central group of five long setae, a group of four long setae submedianly and slightly posterior to the coxa of each foreleg, a similar group of three spines slightly mesal of the coxa of each of the mid and hind legs; a ventral transverse row of four or five long setae near the centre of abdominal segments 2 to 7;

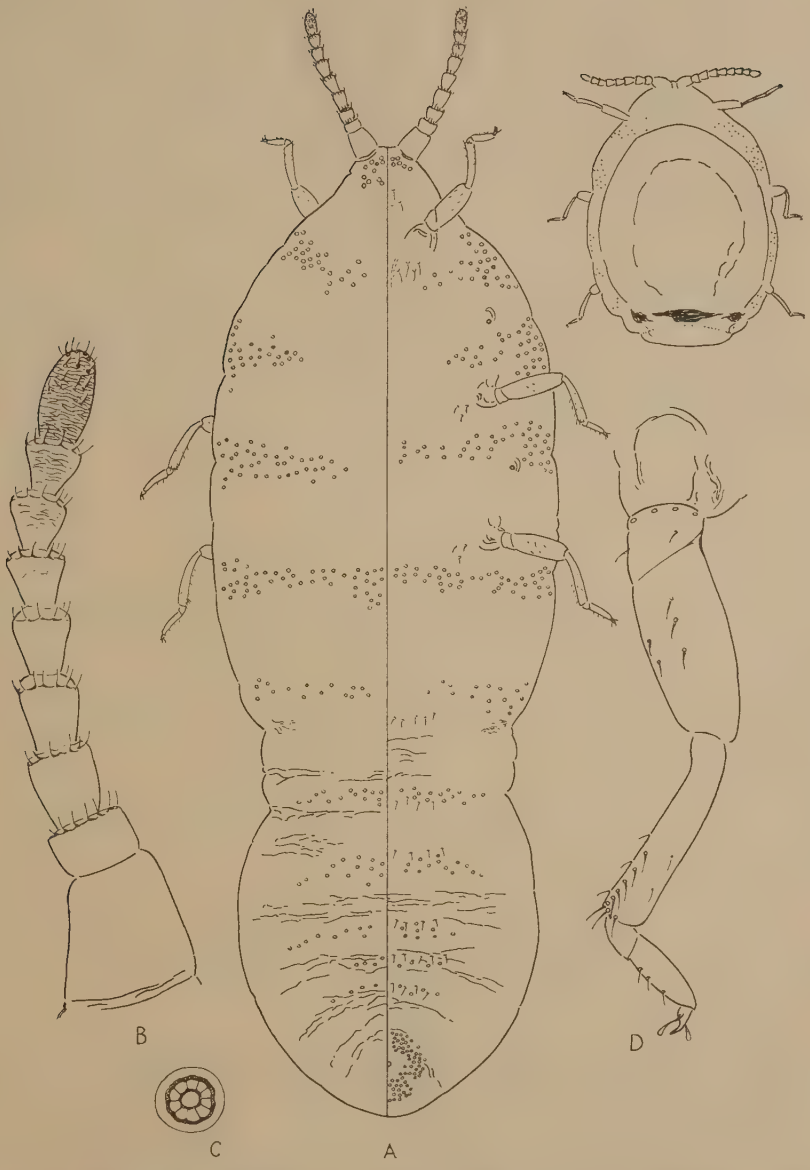

Fig. 2.—*Conifericoccus invaginatus*. A, outline of body (× 49). B, antenna (× 180). C, multilocular disk pore (× 1148). D, leg (× 180). Top right, outline of body with abdomen invaginated (× 38).

other body setae short and scattered. Large multilocular disk pores present both dorsally and ventrally as follows: a small group between the bases of the antennae more or less merging into a transverse band posterior to the antennal bases, a large marginal group narrowing to a transverse band on each thoracic segment, a complete large band on abdominal segments 1 and 2, bands on other abdominal segments with progressively fewer pores but a large ventral group apparently surrounding the vulva. Small simple rim ducts scattered dorsally on abdominal segments posteriorly from the fourth segment. Body posteriorly faintly aereolate. Anal opening atrophied.

Notes.—The abdomen at maturity is invaginated to fill the whole cephalic portion of the body, and the whole becomes hard. Aereolation may be evident on both the dorsal and ventral surfaces and sometimes on other parts of the body. In most instances the pores are less on the ventral surface. Rim ducts are more noticeable on older specimens.

The second stage female has features comparable to species of *Matsucoccus.*

Nymphs are not widely different in general appearance from adult females; the abdomen is proportionately wider and the antennae are 6-segmented. Third stage males are similar in general shape to young adult females but are smaller in size, the multilocular pores are few in number and in single transverse rows. This moults to a "pupal" stage showing wing buds, and this in turn gives rise to the usual winged adult.

Type Reg. No. T 5816 and paratypes Nos. T 5817 to T 5819 in the Queensland Museum.

Conifericoccus notabilis new species

(Figure 3)

Locality and host.—Queensland; Benarkin, on *Araucaria cunninghamii* D. Don, Sept. 1957.

Habit.—On a plantation tree of the host species in a rain-forest area, the encysted second stage occurring in the tissue of a gall of *Araucaricoccus queenslandicus.*

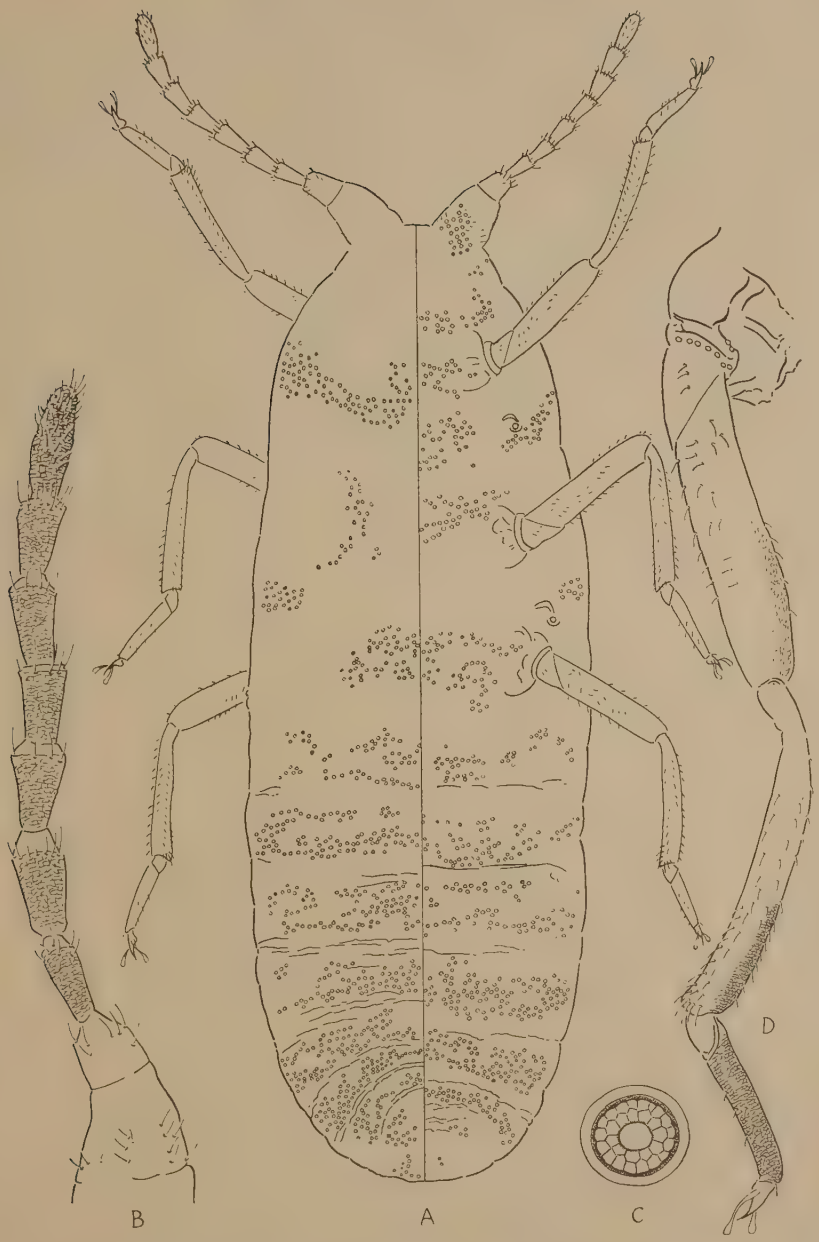

Fig. 3.—*Conifericoccus notabilis.* A, outline of body (× 46). B, antenna (× 110). C, multilocular disc pore (× 1157). D, leg (× 110).

Recognition characters.—Adult female membranous, elongate-oval, length of slide specimen 3·0 mm, width 1·2 mm. Antennae well developed, long, 9-segmented; segment 1 largest; segments 3 to 8 of similar shape and size, each widest anteriorly; segment 9 narrowest, elongate-oval; surface of segments 3 to 9 reticulate, most conspicuous on segment 9; several groups of fine setae on segment 1, similar setae in an apical ring on segments 2 to 8, many scattered setae on segment 9. Mouth parts absent. Legs well developed, slightly longer than antennae; coxa large; trochanter small, with six or seven basal simple pores; femur sub-cylindrical, with some longitudinal and scattered rows of small setae; tibia subequal in length to femur, sub-cylindrical, with many setae; tarsus 2-segmented, segment 1 small, segment 2 subequal to or slightly longer than half the length of the tibia, with a few scattered setae; claw long and slender, with two digitules; surface reticulation pronounced on tarsus, less pronounced on tibia and less still on femur; legs subequal in size, the hind legs being barely the longest. Thoracic spiracles small, accompanied by a sclerotized rod; abdominal spiracles small. Numerous large multilocular pores, with single centres, on both dorsal and ventral surfaces of head region, on each thoracic and abdominal segment but fewer in number on posterior segments. Anal opening atrophied.

Notes.—Two specimens only are available. Although extracted from the second stage cyst they are fully developed. Median ventral segmental setae are present but are obscured by folding of the body in the slide mounts. A few setae occur on the coxae and trochanters and on the body medianly from the coxae.

This species differs from *C. invaginatus* in that the multilocular pores are much more numerous, and these are not obviously arranged in a band around the vulva region, the legs are longer and more elongate, the tarsal claw is linear, reticulation is pronounced on the legs and the second stage individuals are embedded within host tissue.

Type Reg. No. T 5820 and paratype No. T 5821 in the Queensland Museum.

Conifericoccus agathidis new species

(Figure 4)

Locality and host.—Queensland; Amamoor, on *Agathis robusta* (C. Moore) F. M. Baill., Oct. 1959.

Habit.—Insects numerous on young foliage of plantation trees.

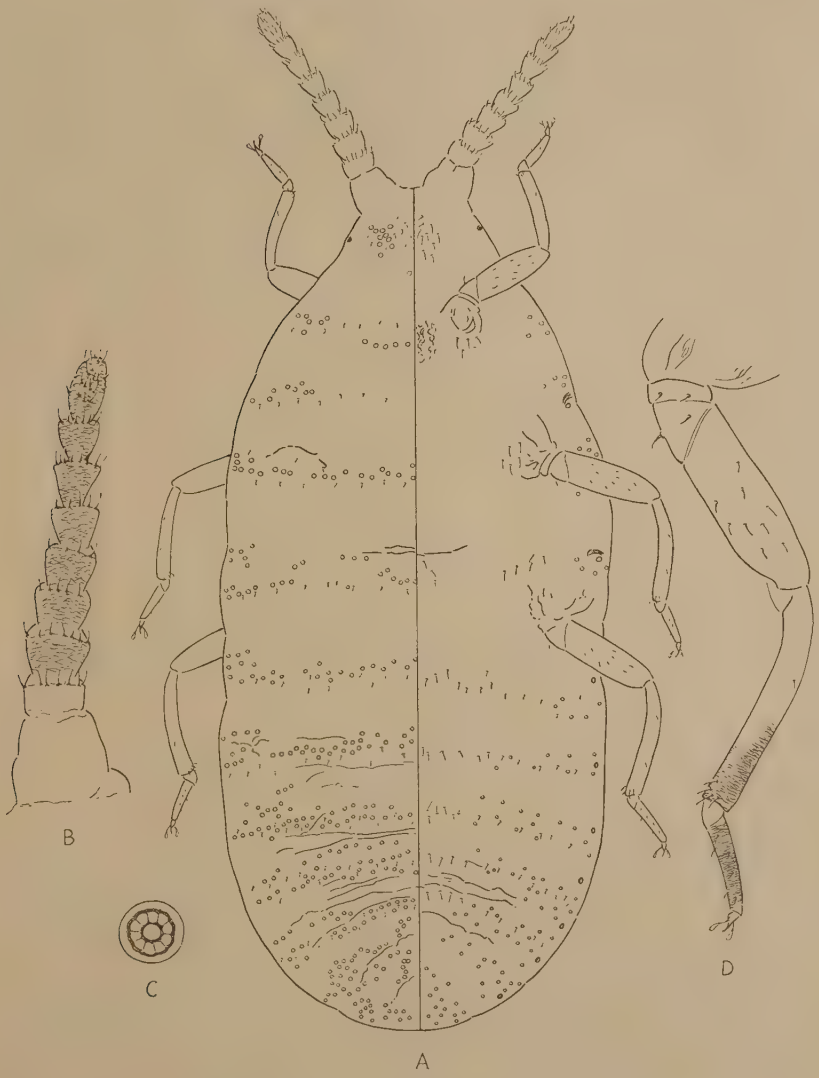

Fig. 4.—*Conifericoccus agathidis.* A, outline of body (× 47). B, antenna (× 89). C, multilocular disk pore (× 1106). D, leg (× 89).

Recognition characters.—Adult female membranous, elongate-oval, body length of slide specimen 3·0 mm, width 1·35 mm. Antennae terminal, well developed, length 0·7 mm; segment 1 longest and widest, lateral margins slightly anteriorly convergent; segment 2 shortest, transversely rectangular; segment 3 subquadrate or with lateral margins slightly anteriorly divergent; segments 4 to 8 subequal in length with lateral margins progressively more divergent; segment 9 narrowest, elongate oval, one-and-a-half times as long as segment 8; segments 3 to 9 with transversely reticulate markings. Antennal setae in a transverse median ring on segment 1, shorter than on segment 2; in an apical ring containing 10 or 11 on segments 2 to 6; similar and containing 11 to 13 on segments 7 and 8; shorter and irregularly placed on anterior two-thirds of segment 9. Eye spots small, latero-posteriorly to bases of antennae. Mouth parts atrophied. Legs well developed, similar in shape and size, total length 0·9 mm. Coxa broad, with two large setae on inner surface, anterior and posterior surfaces each with a few short setae. Trochanter with a large ventral seta. Femur 0·3 mm long, width one-quarter of the length, with some widely spaced fine setae. Tibia 0·3 mm long, width less than half that of femur, cylindrical, basal one-third curved; setae widely spaced, more or less in four longitudinal rows, two on each of the inner and outer margins, distal setae of the inner rows long; surface with irregular transverse to reticulate striations. Tarsi 2-segmented; segment 1 triangular, setae absent; segment 2 with a few scattered fine setae and many irregular transversely reticulate striations. Claw broad basally, narrow, curved and pointed distally, the pair of digitules large and spathulate. Thoracic spiracles simple, orifices round, pores absent, with an associated curved thickened band. Abdominal spiracles in seven pairs, simple and small. Body pores large, multilocular with simple centres; widely spaced on ventral surfaces of head; as an irregular transverse dorsal band on each thoracic segment and continuing latero-ventrally; pores on abdominal segments more numerous in the dorsal bands on segments 1, 2 and 3 than on thorax; bands on other segments anteriorly arched; in transverse bands on ventral surface becoming more numerous on posterior segments. Small rim-ducts widely spaced, in irregular transverse rows dorsally on posterior abdominal segments. Body setae on the head scattered in a transverse row on each thoracic segment and in an irregular transverse row on each abdominal segment; variable though mostly long on ventral surface; an irregular central group of about 20 long setae on the head, four to six near the base of each leg, four medianly on metathorax, five or six in a short transverse median row on abdominal segments these rows continued laterally with short setae. Anal opening atrophied.

Notes.—Antennal segments show slight variations amongst mounted specimens with respect to shape and size of segments 1, 2 and 3. Rudimentary mouthparts are sometimes present. The pores dorsally on the head, though comparatively widely spaced, may appear as a broad longitudinal band merging into a transverse band. The dorsal band on each thoracic segment may appear as an irregular line, the number of pores in the bands vary and may in these and the dorsal abdominal bands sometimes appear to be in two irregular lines. The ventral group of long setae on the head may vary from 12 to 20 in number.

This species resembles *C. invaginatus*. The main differences shown are that the setae are more numerous on the head, the legs are longer than the antennae, the eggs are laid in a mealy sac without the abdomen becoming invaginated and the insects infest young foliage on which they make pimple-like swellings.

Type Reg. No. T 5822 and paratypes Nos. T 5823 to T 5825 in the Queensland Museum.

Acknowledgement

Mr. William Manley, Departmental Illustrator, made all the drawings.

(Received for publication March 25, 1960)

ADDENDUM to "Studies of the Coccoidea. 10. New Species of Diaspididae," by A. R. Brimblecombe, this Journal, Vol. 16, p. 381.

DORIOPUS new genus

Generic type.—Doriopus bilobus Brimblecombe.

Characters.—Adult female enclosed in the enlarged and heavily sclerotized exuvium of the second stage nymph, subcircular, membranous. Pygidium with median pair of large contiguous lobes. Basal scleroses and paraphyses absent. Gland spines in a continuous row on pygidial and prepygidial segments. Dorsal ducts few and indistinct.

Notes.—This genus has relationship with the other Australian genera *Hybridaspis* and *Hemiaspidis* in having the adult enclosed in the second exuvium but differs from these in that the gland spines on the pygidial margin are in a continuous series and none are broad with a divided apex.

QUEENSLAND HOST RECORDS FOR THE DACINAE (FAM. *TRYPETIDAE*). SECOND SUPPLEMENTARY LISTS.

By A. W. S. MAY, M.Agr.Sc.*

SUMMARY

New host records compiled since 1957 are presented.

Strumeta tryoni **(Frogg.), the most important of the economic species in Queensland, has now been bred from 117 hosts.**

Records of males of five species attracted to flowers of Orchidaceae **and** Passifloraceae **are given in an Appendix.**

INTRODUCTION

Two papers concerned with host records for the Dacinae have been published (May 1953, 1957*a*). In this paper records compiled since 1957 are presented in the same form—e.g. 2:1:3 (+ 2) denotes 2 commercial, 1 ornamental and 3 wild hosts with 2 further wild host records doubtful or unconfirmed for that species.

Three new records are included for *Strumeta tryoni* (Frogg.), increasing to 117 the number of hosts for this species.

Since the publication of the last host lists, six species of Dacinae have been described and a new species record for Queensland established (May 1957*b*). No hosts are known for these. Of the 51 species of Dacinae now recorded from Queensland, wild hosts of 16 are still unknown.

Records of males of five species attracted to flowers of Orchidaceae and Passifloraceae Passifloraceae are given in an appendix.

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SECTION 1

Fruit Fly-Host List

AFRODACUS Bezzi

Afrodacus jarvisi (Tryon)

Ornamental Host

Myrtaceae

Psidium cattleianum Sabine—Cherry guava: February. An occasional specimen was bred among large numbers of *S. tryoni* and *S. humeralis*.

Wild Host

Myrtaceae

Eugenia suborbicularis Benth.: November. Large numbers emerged from this host in association with *S. tryoni* and *S. kraussi*.

(6:1:5 (+ 1))

AUSTRODACUS Perk.

Austrodacus cucumis (French)

Commercial Host

Cucurbitaceae

Trycosanthes anguina L.—Guada bean: February.

Wild Host

Cucurbitaceae

Lagenaria siceraria Standl.—Bottle-gourd: April. Females seen to oviposit in this fruit. Larval development was not established.

(10:0:2 (+ 2))

HETERODACULUS Hardy

Heterodaculus visendus Hardy

Wild Host

Guttiferae

Garcinia gibbsae Sp. Moore—a Native mangosteen: December.

(0:0:3)

Strumeta humeralis (Perk.)

Commercial Hosts

Annonaceae

Annona squamosa L.—Custard apple: April—an occasional specimen among a series of *S. tryoni.*

Vitaceae

Vitis labruscana L. H. Bail.—Isabella grape: November, Central Queensland.

Ornamental Host

Myrtaceae

Psidium cattleianum Sabine.—Cherry guava: February.

(22:6:20 (+ 1))

Strumeta kraussi Hardy

Wild Hosts

Euphorbiaceae

Fontainea picrosperma C. T. White: January.

Flacourtiaceae

Baileyoxylon lanceolatum C. T. White: February.

Myrtaceae

Eugenia suborbicularis Benth.: November, Coen, North Queensland.

Psidium guajava L.—Guava: April—a very occasional specimen among a large series of *A. jarvisi, S. humeralis* and *S. tryoni.*

Rutaceae

Acronychia sp. aff. *laevis* Forst.: January, North Queensland. This host is very close botanically to *Acronychia laevis* Forst. of Southern Queensland, a common host of *S. halfordiae* (Tryon).

Acronychia vestita F. Muell.: October.

(0:2:25)

Strumeta musae (Tryon)

Wild Host

Myrtaceae

Psidium guajava L.—Guava: April, Cairns. An occasional specimen bred among a large series of *A. jarvisi, S. humeralis* and *S. tryoni.* An earlier record by Hardy (1951), considered as doubtful (May 1953), is now confirmed.

(2(+ 1):0:2(+ 1))

Strumeta tryoni (Frogg.)

Ornamental Host

Rosaceae

Prunus cerasifera Ehrh. var. *pissardii* Koehne.—Ornamental plum: November.

Wild Hosts

Rutaceae

Acronychia acidula F. Muell.—Scrub lemon: October—occasional specimens among a series of *S. kraussi.*

Acronychia sp. aff. *laevis* Forst.: January, Evelyn Tableland area, North Queensland. In an earlier paper (May 1953, p. 69), *Acronychia laevis* Forst. was considered a doubtful record for *S. tryoni. Acronychia* sp. aff. *laevis* is not readily separated botanically from *A. laevis* Forst. which was described from Southern Queensland.

(41:11:65(+ 3))

SECTION 2

Host—Fruit Fly List

Botanical Name	Common Name	Species Recorded	Remarks
ANNONACEAE			
Annona squamosa L.	Custard apple	*Strumeta humeralis*	Occasional specimens
CUCURBITACEAE			
Lagenaria siceraria Standl.	Bottle-gourd	*Austrodacus cucumis*	Oviposition record only
Trycosanthes anguina L.	Guada bean	*Austrodacus cucumis*	
EUPHORBIACEAE			
Fontainea picrosperma C. T. White		*Strumeta kraussi*	
FLACOURTIACEAE			
Baileyoxylon lanceolatum C. T. White		*Strumeta kraussi*	
GUTTIFERAE			
Garcinia gibbsae Sp. Moore	A Native mangosteen	*Heterodaculus visendus*	
MYRTACEAE			
Eugenia suborbicularis Benth.		*Afrodacus jarvisi*	In large numbers
		Strumeta kraussi	
Psidium cattleianum Sabine	Cherry guava	*Afrodacus jarvisi*	Occasional specimens
		Strumeta humeralis	Bred in appreciable numbers
Psidium guajava L.	Guava	*Strumeta kraussi*	An occasional specimen
		Strumeta musae	A confirmed record
ROSACEAE			
Prunus cerasifera Ehrh. var. *pissardii* Koehne	Ornamental plum	*Strumeta tryoni*	
RUTACEAE			
Acronychia acidula F. Muell.	Scrub lemon	*Stumeta tryoni*	Occasional specimens
Acronychia sp. aff. *laevis* Forst.		*Strumeta kraussi*	
		Strumeta tryoni	
Acronychia vestita F. Muell.		*Strumeta kraussi*	
VITACEAE			
Vitis labruscana L. H. Bail.	Isabella grape	*Strumeta humeralis*	

ACKNOWLEDGEMENTS

Several officers of the Departments of Forestry and Agriculture and Stock, and Mr. J. L. H. Wassell, Coen, have assisted with collections of native fruits. The staff of the Botany Section has identified all botanical material and has also checked these lists for publication.

This assistance is gratefully acknowledged.

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APPENDIX

Flower—Male Fruit Fly List

Records of male Dacinae attracted to flowers are presented below. Three records for *Afrodacus jarvisi* (Tryon) attracted to Anacardiaceae, Orchidaceae and Passifloraceae were published earlier (May 1953).

Botanical Name	Common Name	Species Recorded	Remarks
ORCHIDACEAE			
Dendrobium superbiens G. Reichb.	Golden orchid	*Strumeta breviaculeus*	In large numbers
		Strumeta bryoniae	Few specimens only
		Strumeta pallidus	Few specimens only
		Strumeta tryoni	Few specimens only
PASSIFLORACEAE			
Passiflora maliformis L.	Sweet calabash	*Afrodacus jarvisi*	In large numbers
		Strumeta tryoni	Occasional specimens

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SURVEY OF PENICILLIN IN MARKET AND MANUFACTURING MILK

I. INTRODUCTION

The increase in penicillin sensitivity in the community has directed attention to the possible ingestion of this antibiotic in certain foodstuffs, and in particular milk.

Richards (1958) conducted a penicillin survey of raw milk supplied to receiving depots in New South Wales. He tested 400 samples and recorded 1·5 per cent. positive results, the range being 0·5–2·55 I.U./ml.

In the survey discussed in this note, metropolitan and country pasteurized milk samples, raw tanker samples, individual raw milk samples, and cheese factory samples were screened for residual antibiotics.

II. MATERIALS AND METHODS

Petri dishes—flat-bottom plastic dishes.

Bacillus subtilis suspension—standardised inoculum of culture ATCC6633.

Filter paper discs penicillin impregnated for reference standards—specially prepared.

Filter discs, unimpregnated blanks, sterile—diameter 0·25 in. with high absorbability—for absorption of test portion of milk.

Assay seed agar—Bacto B263 with proteose-peptone replacing Casitone.

Basal agar layer—Bacto B270.

Petri dishes were poured with 10 ml basal agar. "Seed" agar prepared by inoculating 50 ml portions of the medium with 5 ml of a 24 hr broth cultures of *Bacilus subtilis* ATCC6633 was then poured into the petri dishes at the rate of 6 ml per dish. The petri dishes after being allowed to set were transferred to the refrigerator until required.

A test was performed in the following manner. Samples of milk were heated to 180° F and cooled to room temperature. A sterile disc was picked up with sterile forceps and the edge dipped into the sample, allowing the disc to wet by capillary attraction and avoiding the pick-up of excess milk. The disc was then placed on the agar surface of one of the prepared petri dishes.

A blank and a standard penicillin disc were also placed on each dish. The dishes were then incubated at 35 ± 5° C for four hours. At the conclusion of the incubation the dishes were examined for zones. These were measured and the values of the unknown calculated.

III. RESULTS

(a) Market and Manufacturing Milks

The number of milks examined in each category was as follows:—

Category	Number
Pasteurized	284
Tankers	191
Individual suppliers	324
Individual cows	12
Cheese factory suppliers	21
Total	832

In no case was even a trace of a zone observed.

(b) Milk from Penicillin-treated Cows

Individual quarters of cows suffering from mastitis were treated with penicillin preparations and the milk withdrawn at recorded intervals of time. The results were as follows:—

Case 1.—The affected quarter was treated with 50,000 units of procaine penicillin. A sample of milk withdrawn at the end of 24 hours tested 100 I.U./ml penicillin. A 48 hr sample showed no trace of residual penicillin.

Case 2.—The affected quarter was treated with 50,000 units of a commercial penicillin preparation. No residual penicillin was detected at the end of 24 hours.

Case 3.—The quarter was treated with 50,000 units of penicillin. A 12 hr sample of milk exhibited 100 I.U./ml of penicillin.

Case 4.—The quarter was treated with 50,000 units of penicillin. At the end of 9 hours the fore-milk was negative but the strippings showed a residual penicillin content of over 15 I.U./ml.

IV. DISCUSSION

The work carried out on market and manufacturing milk indicates that residual penicillin levels of 1 I.U./ml or more are very rare. Residual penicillin at a level less than 1 I.U/ml could be present but the method was not sensitive enough to detect it. In addition, the bulking of milk tends to reduce the level of penicillin to an unmeasurable concentration.

The cow experiments show that as a rule penicillin in measureable quantities persists in the milk from 24 to 48 hours and that the bulk of penicillin is to be found in the strippings.

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A NOTE ON THE PRESERVATION OF A SOLUTION OF MOLASSES AND UREA IN WATER

In the drier areas of Queensland, pasture growth is seasonal. In most years the only feed available for 3-6 months is pasture at the standing hay stage on which even non-breeding stock lose weight. Under these conditions a response is obtained to protein supplementation, as shown by Marston (1932) with wool growth of sheep. In cattle, the response has not been so clearly demonstrated (Anon. 1959, p. 79).

A possible method of supplementation is one in which the supplement is added to the drinking water. Although conventional forms of protein cannot be provided in this manner, urea would be suitable because of its high solubility.

If treated water is supplied to cattle which are grazing extensive areas and having only one drink daily, the concentration of urea in the water must be such that urea intake is below the minimum level which could cause acute toxicity. This level, of the order of 0·3 to 0·4 g urea per Kg body-weight (Clark, Oyaert, and Quin 1951—sheep; Dinning *et al.* 1948—bovine; Beames, unpublished data—bovine), is only slightly greater than the amount which would normally be fed to cattle on poor pastures. For optimum utilization and to minimise toxicity it is desirable to supply molasses with the urea (Mills, Lardinois, Rupel, and Hart 1944).

In the preparation of a stable solution of molasses and urea in water, the major difficulty is the prevention of bacterial and fungal growth. A wide range of disinfectants were tested in this laboratory and all were found unsuitable because of either ineffectiveness at economically reasonable levels or toxicity at effective levels.

It was found that an effective way of ensuring the stability of a molasses/urea/water solution was to keep it sufficiently alkaline. This was achieved by first saturating the water with slaked lime and then adding the molasses and urea. To prevent absorption of carbon dioxide and hence a lowering of pH, a protective surface was necessary. This was formed by a float containing cetyl alcohol. Under these conditions the pH of such a solution remained between 10 and 11 for at least 14 days.

Some sedimentation occurred. A solution containing 1 per cent. molasses, 0·2 per cent. urea and 0·15 per cent. calcium oxide in distilled water gave a dry-matter precipitate of 0·183 per cent. by weight. The supernatant liquid contained 0·09 per cent. calcium and all the nitrogen from the added urea

and molasses. No measure was made of the carbohydrate content of the supernatant liquid. (The normal reaction of sucrose and reducing sugars in alkaline solutions is to form other soluble carbohydrates, the exact composition of which is rather ill-defined (Honig 1953).)

Bacterial counts of a molasses/urea/lime solution prepared in this manner showed no growth over a period of four days. Without the addition of lime, the solution after one day contained 105 x 10^7 micro-organisms per ml, consisting of 91 per cent. cocci (mostly diplococci), 4 per cent. bacilli and 5 per cent. yeasts.

In the field this method is applicable where drinking water is supplied by troughing and where alternative surface water is not available. The lime, molasses and urea could be added by first passing the water over a lime bed and then metering a concentrated molasses urea solution into the water by means of one of several machines available on the market in Queensland for adding soluble phosphate to the drinking water. All containers could be provided with a cetyl alcohol float.

Studies on the effect on cattle of this mixture in the drinking water are in progress.

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RIPENING OF RYAN AVOCADO FRUITS

I. INTRODUCTION

The Ryan variety of avocado is usually marketed from July onwards and it has been claimed that it does not ripen properly if allowed to become too mature, this period being from about the end of September. It was decided to investigate the changes in the respiration rate that occur in the fruit of this variety with respect to maturity and to use this pattern as a measure of the progress of ripening (Biale 1947). The effect of added ethylene on the respiration rate was also studied at various maturities.

II. METHODS AND MATERIALS

The respiration rate was measured by the Pettenkofer method as described by Turner (1949).

The respiration chambers consisted of 6 in. x 6 in. specimen jars clamped to steel plates fitted with rubber gaskets and were similar in type to although smaller than the one illustrated by Biale and Shepherd (1941). The volume of each was approximately 5·5 l. Excessive withering of the fruit was prevented by the inclusion of a humidifier and carbon dioxide was removed from the air by a caustic soda bubbler. A rate of flow of 80 ml/min of the ventilating air was measured by a manometer-type flow-meter which was calibrated by the method of Meuron (1941). The flow rate was adjusted when necessary by a screw clip to each manometer.

The fruit was selected from two trees on a property in the Redlands area. Picks were made at intervals commencing on July 21, 1959. In all seven picks were made, but because of breakdowns Picks 1, 3 and 6 were abandoned before results could be completed. Actual picking dates were: Pick 1, July 21; Pick 2, August 12; Pick 3, September 3; Pick 4, September 28; Pick 5, October 19; Pick 6, November 9; Pick 7, November 16.

In all cases the fruit was picked and placed in the respiration chambers on the same day. Measurements of respiration rates were commenced the following day. At each pick the respiration rates of 6 fruits were measured while treated with 1,000 p.p.m. of ethylene in the ventilating air stream and the rates of a further 6 were measured in CO_2 free air. At Pick 7, 8 fruits were measured in air and 4 in air with ethylene. The rates were measured each day Monday to Friday. This proved quite satisfactory although some difficulty occurred when the climacteric peak occurred during the week-end.

The results of Biale (1946) showed that temperatures of 25°C and 5°C gave non-typical climacteric curves. This author recommended a temperature of 15°C (59° ± 1°F), and this was used in this investigation.

III. RESULTS

All fruit gave a typical climacteric curve as described by Biale (1946, 1947). In all ethylene-treated fruit the peak of the climacteric curve was reached in 4-7 days (generally 5), but with other fruit the time was somewhat variable. The lengths of time to reach the climacteric peak are shown in Table 1.

Table 1

TIME TO REACH CLIMACTERIC PEAK (DAYS)

Pick No.	Air		Ethylene	
	Tree 1	Tree 2	Tree 1	Tree 2
2	14, 15, 13	—, 16, 17	5, 7, 7	4, 4, 4
4	19, 26, 26	—, 18, 17	5, 5, 5	5, 6, 5
5	19, 17, —	12, 21, 12	5, 5, 5	6, 5, 5
7	29, 25, 19, 29	25, 22, 34, 24	5, 4	5, 5

All fruit softened satisfactorily and reached a satisfactory eating-ripe stage. With ethylene-treated fruit this was 2 days after the peak of the climacteric. With other fruit, softening did not occur until 3 or 4 days after the climacteric.

IV. DISCUSSION

It will be seen from the results that over the maturities used the variety ripened satisfactorily. Whenever ethylene was not used rather a long time was required to reach eating ripeness. This could be one of the reasons for the reported non-ripening of the variety.

Ripening would be considerably hastened at atmospheric temperatures, which would be somewhat higher than those used experimentally. It is possible that atmospheric temperatures are high enough to disrupt the ripening mechanism, but this requires further investigation. Further evidence that temperature may be important is given by the fact that the non-ripening is supposed to occur late in the season when atmospheric temperatures are rising to a maximum. Under atmospheric conditions, dehydration would be quite severe and may be sufficient to disturb normal ripening.

In this investigation, despite the high humidity used and the length of time required for the climacteric to occur, fungal infections did not cause any premature loss. However, it is possible that fungal attack could be important in the ripening of fruit under atmospheric conditions where temperatures would be higher than those used experimentally.

In view of the results obtained with ethylene it seems that ripening could be hastened and a more attractive product marketed by the use of this gas. Not only would the fruit be more attractive because of the shorter time it was held but it would be possible to guarantee when fruit would be edible because of the more even ripening.

Fruit picked on August 12 reached a climacteric peak after 15 days. This length of time may be taken as normal. The following pick was made on September 28 and at this time the tree was flowering heavily and growing vigorously. The time for this pick to reach the climacteric was 21 days. The next pick was made on October 19, when the heavy flowering had finished and the initial burst of heavy growth had almost finished. The time for this pick to reach the climacteric was 16 days. The final pick was made on November 16. At this stage the trees had ceased to show vigorous growth, another burst of which occurred shortly after this date. The time for this pick to reach the climacteric was 26 days.

In view of the above evidence it is suggested that the time taken for fruit to reach the climacteric may in some way be connected with the vegetative state of the tree. It is also suggested that the "non-ripening" may be caused by picking the fruit at or just prior to a period of reproductive or vegetative growth. It seems, therefore, that care should be taken to avoid picking the fruit at this time. Further work would be required to clear up this point.

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